

Daily report

24-04-2020

Analysis and prediction of COVID-19 for EU-EFTA-UK and other countries

Foreword

The present report aims to provide a comprehensive picture of the **pandemic situation of COVID-19** in the EU countries, and to be able to foresee the situation in the next coming days.

We employ an **empirical model**, verified with the evolution of the number of confirmed cases in previous countries where the epidemic is close to conclude, including all provinces of China. The model does not pretend to interpret the causes of the evolution of the cases but to permit the **evaluation of the quality of control measures made in each state** and a **short-term prediction of trends**. Note, however, that the effects of the measures' control that start on a given day are not observed until approximately 7-10 days later.

The model and predictions are based on two parameters that are daily fitted to available data:

- ✓ α : the velocity at which spreading specific rate slows down; the higher the value, the better the control.
- ✓ K : the final number of expected cumulated cases, which cannot be evaluated at the initial stages because growth is still exponential.

We show an individual report with 8 graphs and a table with the **short-term predictions** for different countries and regions. We are adjusting the model to **countries and regions** with at least 4 days with more than 100 confirmed cases and a current load over 200 cases. The **predicted period** of a country depends on the number of datapoints over this 100 cases threshold, and is of 5 days for those that have reported more than 100 cumulated cases for 10 consecutive days or more. For short-term predictions, we assign higher weight to last 3 points in the fittings, so that changes are rapidly captured by the model. The whole methodology employed in the inform is explained in the last pages of this document.

In addition to the individual reports, the reader will find an initial dashboard with a brief analysis of the situation in EU-EFTA-UK countries, some summary figures and tables as well as **long-term predictions** for some of them, when possible. These long-term predictions are evaluated without different weights to datapoints. We also discuss a specific issue every day.

Martí Català
Pere-Joan Cardona, PhD
*Comparative Medicine and Bioimage Centre of
Catalonia; Institute for Health Science Research
Germans Trias i Pujol*

Clara Prats, PhD
Sergio Alonso, PhD
Enric Álvarez, PhD
Miquel Marchena
Daniel López, PhD
*Computational Biology and Complex Systems;
Universitat Politècnica de Catalunya - BarcelonaTech*

With the collaboration of: Guillem Álvarez, Oriol Bertomeu, Laura Dot, Lavínia Hriscu, Helena Kirchner, Daniel Molinuevo, Pablo Palacios, Sergi Pradas, David Rovira, Xavier Simó, Tomás Urdiales

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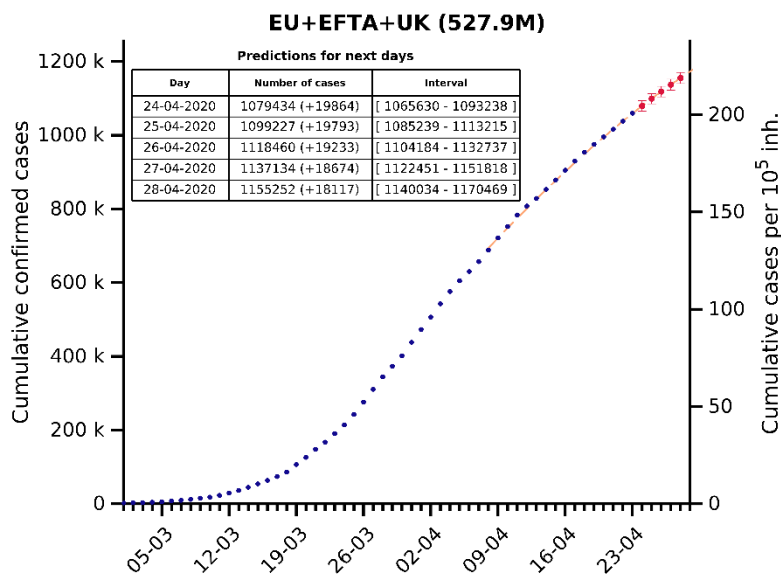
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(0) Executive summary – Dashboard

Global EU+EFTA+UK trends and needs

EU+EFTA+UK countries are following the trend of previous days, arriving at the top of a new peak in the decrease. As expected, **this peak seems lower than previous ones**, which is good news. Predictions also indicate this decreasing dynamic, **situating daily new cases just beneath the level of 20,000 daily new cases**.

Long term prediction of **total number of cases (K)** is at the level of **1.6 million**. If this is confirmed the next days, **we would be at 65 % of this value**. Nevertheless, it must be kept in mind that final tail is long, as the slope of the curve is expected to decrease slower than a few weeks ago.



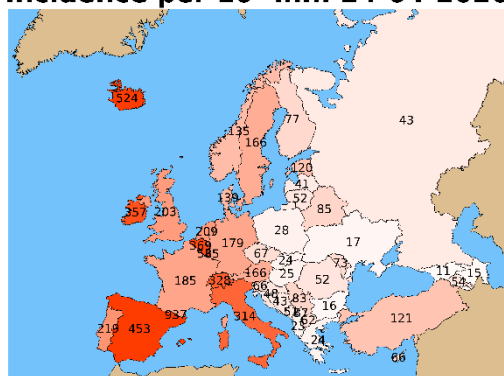
Spanish government has changed the criteria on data reporting and the historical series has break. The whole series will be corrected the next days. Meanwhile, detailed reports of Spain will not be included, and all the analysis and predictions for this country should be interpreted with caution. Greek series of reported series also shows a gap, and thus masks any evaluation based on last data about new cases (e.g., evaluation of p is not reliable).

In the Analysis section we present last instalment of this weeks' assessment of real cases and diagnostic rate. Today, we focus on the **comparison between countries whose dynamics is apparently similar** or different but that, when looking at estimated real data, the **resulting picture show the contrary situation**.

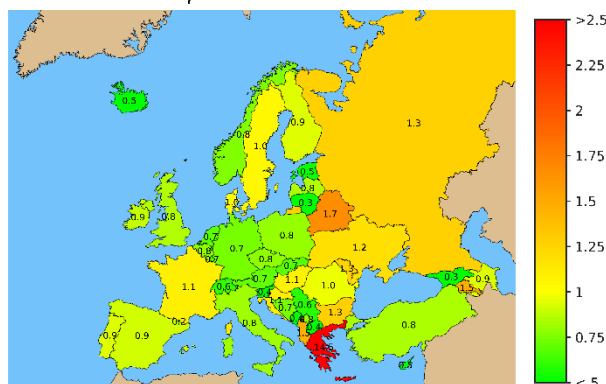
Trends for specific countries

Most worrying situation is found in the four countries with highest EPG: **Ireland** (140), **Belgium** (123), **Spain** (115) and **United Kingdom** (102). There are other ways of evaluating the gravity of the situation, one of them being the number of deaths. Looking at last data on number of deaths in a single day, highest value corresponds to **United Kingdom** (638) followed by **France** (516), **Italy** (464), **Spain** (440) and **Germany** (227).

Incidence per 10⁵ inh. 24-04-2020



ρ 23-04-2020



Situation and trends per country

Table of current situation in EU countries, according to data published by ECDC on April 15th. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) from worst (red) situations according to each of the variables.

Country	Reported data						Indexes		
	Cumulative cases	Attack rate /10 ⁵ inh.	Cumulative deaths	Mortality /10 ⁵ inh.	Active cases (last 14 days)	14-day attack rate /10 ⁵ inh.	Mean $\rho^{(1)}$	EPG ⁽²⁾	EPG2 ⁽²⁾
Spain	213,024	459.6	22,157	47.8	60,578	130.7	0.88	115.3	101.6
Italy	189,973	319.7	25,549	43.0	46,347	78.0	0.83	65.1	54.3
Germany	150,383	183.6	5,321	6.5	36,858	45.0	0.68	30.7	20.9
United Kingdom	138,078	207.8	18,738	28.2	73,001	109.9	0.93	101.7	94.2
France	120,804	186.7	21,856	33.8	34,470	53.3	0.92	49.0	45.0
Belgium	42,797	376.8	6,490	57.1	17,814	156.8	0.78	122.8	96.2
Netherlands	35,729	210.3	4,177	24.6	13,967	82.2	0.78	64.5	50.6
Switzerland	28,414	331.6	1,267	14.8	4,919	57.4	0.53	30.5	16.2
Portugal	22,353	215.5	820	7.9	8,397	81.0	0.98	79.6	78.4
Ireland	17,607	372.6	794	16.8	10,214	216.1	0.65	139.8	90.4
Sweden	16,755	170.3	2,021	20.5	7,614	77.4	0.97	74.8	72.3
Austria	14,985	172.0	508	5.8	1,737	19.9	0.56	11.3	6.4
Poland	10,511	27.5	454	1.2	4,936	12.9	0.89	11.5	10.3
Romania	10,096	51.0	527	2.7	4,894	24.7	0.85	21.0	17.8
Denmark	8,073	141.3	394	6.9	2,438	42.7	0.91	39.0	35.6
Norway	7,345	136.8	180	3.4	1,185	22.1	0.72	15.9	11.5
Czech Republic	7,188	67.7	213	2.0	1,619	15.3	0.89	13.6	12.1
Finland	4,284	77.8	172	3.1	1,679	30.5	1.03	31.4	32.2
Luxembourg	3,665	636.3	83	14.4	550	95.5	0.60	56.9	33.9
Greece	2,463	22.0	125	1.1	508	4.5	7.45	33.8	251.8
Hungary	2,383	24.4	250	2.6	1,193	12.2	1.09	13.3	14.4
Croatia	1,981	47.0	50	1.2	574	13.6	0.79	10.7	8.4
Iceland	1,789	491.1	10	2.7	141	38.7	0.51	19.9	10.2
Estonia	1,592	121.3	45	3.4	385	29.3	0.42	12.4	5.3
Lithuania	1,410	48.5	40	1.4	455	15.6	0.54	8.5	4.6
Slovenia	1,366	65.7	79	3.8	242	11.6	0.38	4.4	1.7
Slovakia	1,325	24.3	15	0.3	624	11.5	0.53	6.1	3.2
Bulgaria	1,097	15.4	52	0.7	473	6.6	0.98	6.5	6.4
Cyprus	795	67.9	17	1.5	231	19.7	0.46	9.1	4.2
Latvia	778	39.5	11	0.6	189	9.6	1.34	12.8	17.1
Malta	445	103.7	3	0.7	108	25.2	ND	ND	ND
Liechtenstein	82	212.7	1	2.6	3	7.8	ND	ND	ND

Scale									
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	500.0	500.0
Best	Best	Best	Best	Best	Best	Best	0.0	0.0	0.0

⁽¹⁾ Disclaimer: parameter ρ is very sensitive and experiments daily variations. Mean ρ is averaged per 3 consecutive days, but it can still vary the following days. ⁽²⁾ EPG stands for Effective Growth Potential. It is obtained by multiplying attack rate per 10⁵ inhabitants of last 14 days (i.e. density of cases) by ρ (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG2 is a similar index but attack rate of last 14 days is multiplied by ρ^2 .

Highlights for countries with highest number of reported cases

- ✓ Spanish data are under quarantine again, since historical series has broken. This is partially reflected on the analysis by countries, since they are based on ECDC data that have a 1-day delay with respect to local ones. We should wait for the new data that will be reported tomorrow to see if it has been corrected or not.
- ✓ Expected new cases for next days are similar to yesterday's predictions: at the level of 4,000 (UK), 2,700 (Italy), 2,100 (Germany) and 1,400 (France).
- ✓ Spreading rate dynamics also follow expected trends, oscillating around 1 with a period of 1 week.

Time indicators by country

This table summarizes a few time indicators for each country: time since 50 cases were reported, time interval between an attack rate of $1/10^5$ inhabitants and an attack rate of $10/10^5$ inhabitants, and time interval between attack rates of 10 to 100 per 10^5 inhabitants (only for countries that have overtaken this threshold).

Countries	Days since the first 50 cases	Time interval between 1 and 10 cases / 10^5 inh. (days)	Time interval between 10 and 100 cases / 10^5 inh. (days)
Italy	62	11	16
France	56	10	20
Germany	56	12	17
Spain	55	7	12
United Kingdom	52	11	19
Norway	51	9	24
Switzerland	51	9	12
Netherlands	50	11	20
Sweden	50	10	28
Austria	49	10	14
Belgium	49	11	14
Greece	48	18	ND
Iceland	48	5	15
Denmark	46	4	30
Czech Republic	45	11	ND
Finland	44	12	ND
Portugal	44	9	15
Slovenia	44	6	ND
Ireland	43	8	18
Romania	43	14	ND
Estonia	42	5	30
Poland	42	11	ND
Bulgaria	40	14	ND
Luxembourg	40	6	7
Slovakia	40	16	ND
Croatia	39	12	ND
Latvia	38	12	ND
Cyprus	37	12	ND
Hungary	37	11	ND
Malta	36	8	34
Lithuania	35	9	ND
Liechtenstein	30	9	11

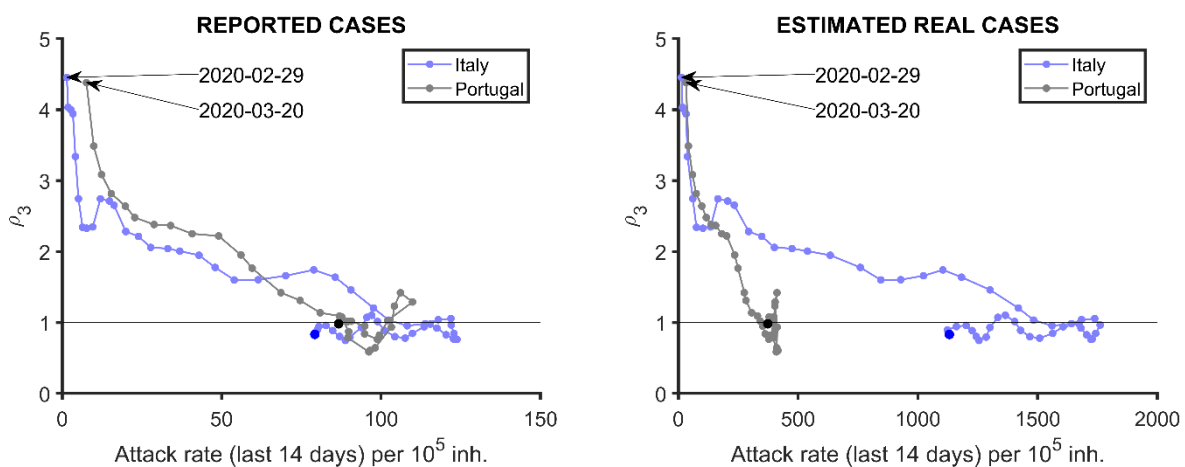
Analysis: Estimating real incidence in European countries (IV) – Comparing reported and estimated situations in different countries.

This week we have been discussing how to provide reliable estimations of real situations of countries, in the context of COVID19 epidemic. In particular, we have developed a robust method for estimating Diagnosis Delay and Diagnostic Rate in different countries. These values allow for an assessment of an incidence that, although not perfect, is closer to reality than the reported one.

The risk situation of countries is given by a combination of their current **3-day average growth rate** (ρ_3 , i.e., mean value of last 3 days), which provides a potential velocity for infection's spreading, and the **14-day attack rate** (A_{14} , i.e., number of new cases per 10^5 inhabitants last 14 days), which is an indicator of potential spreaders. Risk diagrams show the evolution of these variables for each country, and they are an appropriate way of visualizing the risk in terms of history and current situation. In this Analysis, we want **to compare reported and estimated situations in three pairs of countries, using the risk diagram**. For each pair of countries, we show two risk diagrams: first, risk diagram with reported A_{14} in the x-axis; second, risk diagram with estimated A_{14} in the x-axis.

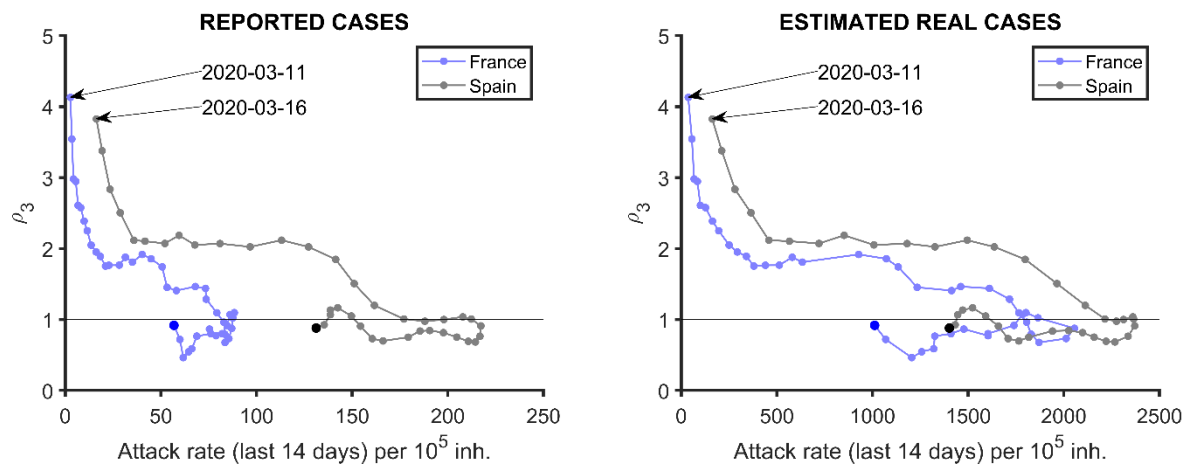
Portugal vs Italy

Portugal and Italy are two countries with a similar reported EPG. Last week, Italy's EPG has been in the range [66.3-78.7] while Portugal's EPG has been in the range [51.8-95.3]. Then, it could be deduced that both countries are in a similar risk situation. Risk diagram in the left show similar trajectories for both countries. Nevertheless, the figure in the right, which corresponds to the risk diagram with estimated cases, shows a totally different picture. According to estimations, **Italy's curve has reached much higher risk values than Portugal**.



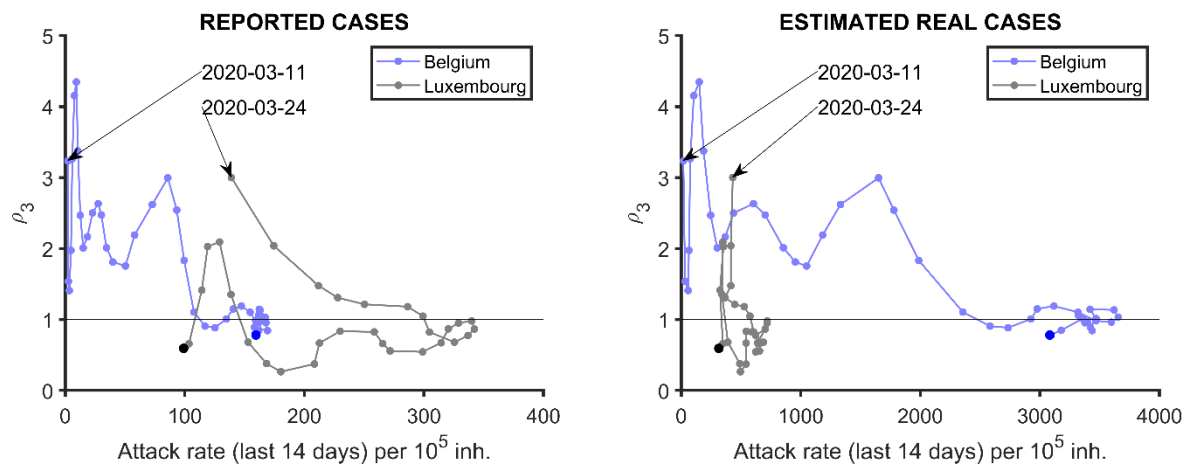
Spain vs France

This pair of countries is an example of the opposite situation. Last week, Spain's EPG has moved in the range [114-164], while France's EPG was in the range [28.1-66.6]. Left plot shows to countries with different risk levels. Nevertheless, if we plot the risk diagram assessed with estimated cases, **both countries converge to a similar pattern**.



Belgium vs Luxembourg

These countries have been in EPG's top five several times the last weeks, with an EPG>100. Let us look at the risk diagrams to see if real situation behind data can be better understood.

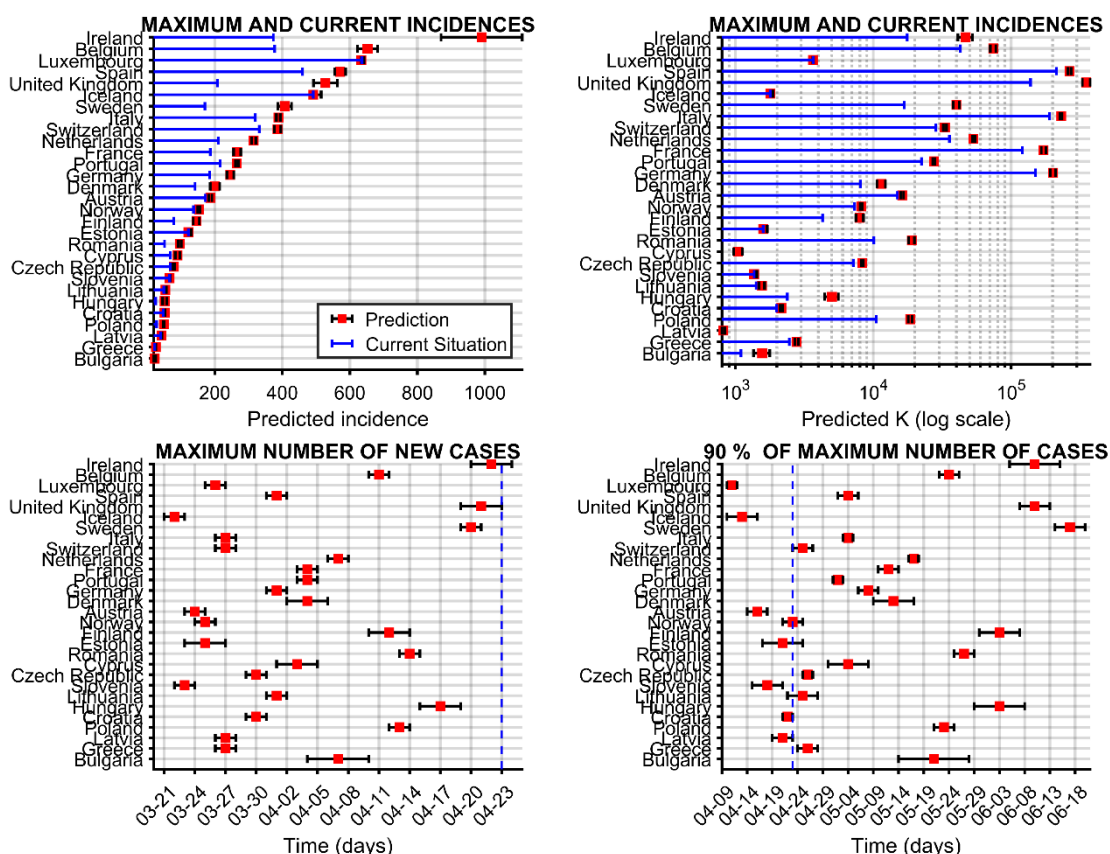


Risk diagram with reported data (left) show that incidence's values have been high, at the level of most affected countries. In fact, according to reported data, Luxembourg would have been in a worse situation than Belgium. However, risk diagram with estimated data provide, again, a totally different situation. **Real situation in Luxembourg would have been similar to that in Portugal, with an intermediate affection.** Contrarily, Belgium shows a situation even worse to the one reported. We must say, as a limitation, that deaths' reporting protocols in this country could be different from other countries, but these data are the basis for the estimation of diagnostic rate. Belgium is reporting deaths in nursery homes at roughly the same level as in hospitals, including cases which are highly dubious. Other heavy-hit regions in Spain report deaths in nursery homes that increase around 40% the total death toll including only suspicious cases. Average values of underreporting of deaths using the comparison of mortality rates during previous years in Spain indicate underreporting of around 20%. This fits the data from Catalonia and Madrid since not all areas are as affected as these two regions. Belgium numbers present similarities with Catalonia and Madrid. It makes sense that it is probably including some deaths correctly, maybe half of them, but not all of them. Therefore, **the estimated situation for Belgium would be an upper level, the real one being between reported and estimated situations.**

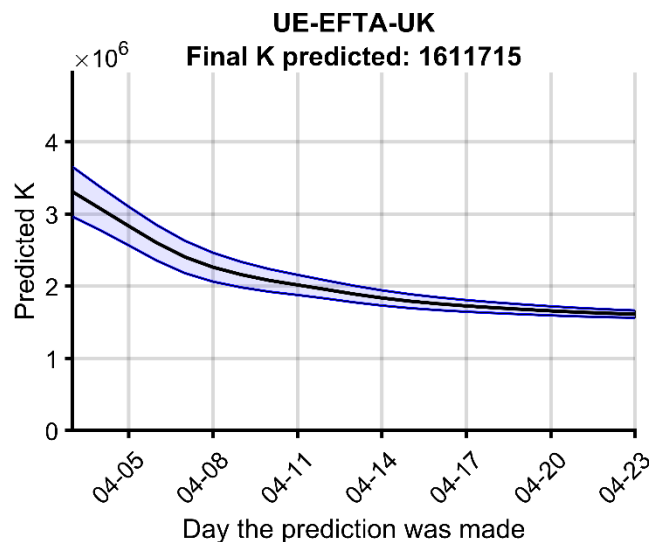
Long-term predictions

Long-term predictions, evaluated with the **whole historical series** and without weighting last 3 points. Up-left: Predictions of maximum incidences per country (total final expected attack rate per 10^5 inh.). Up-right: Predictions of maximum absolute number of cases per country (K, in log scale). Blue lines indicate current situation. Bottom-left: Time in which peak in new cases was achieved / will be achieved. Bottom-right: Time at which 90 % of K was achieved / will be achieved. Blue dotted line indicates current date. See details in Report from 11th April 2020.

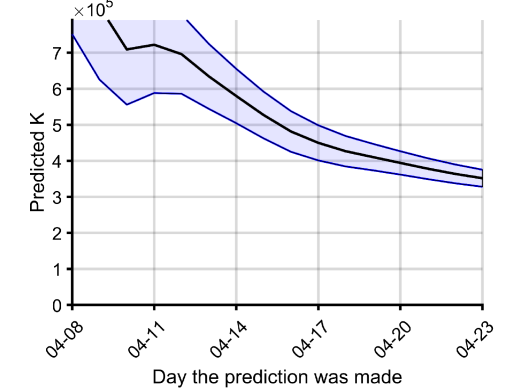
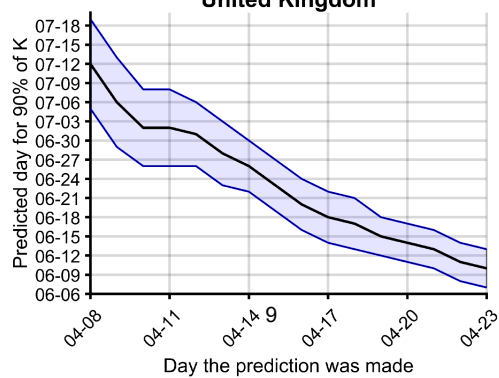
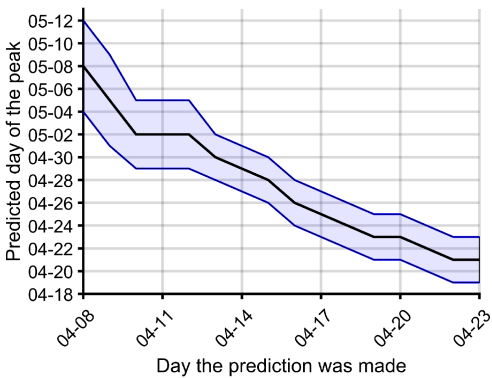
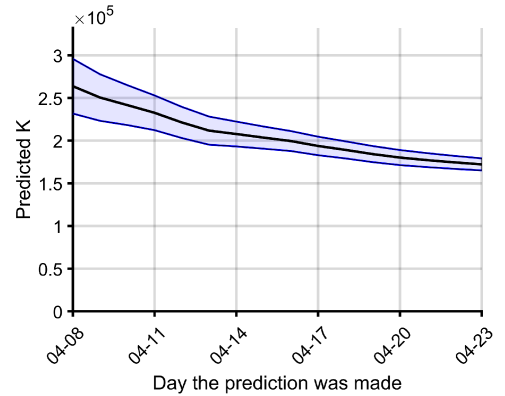
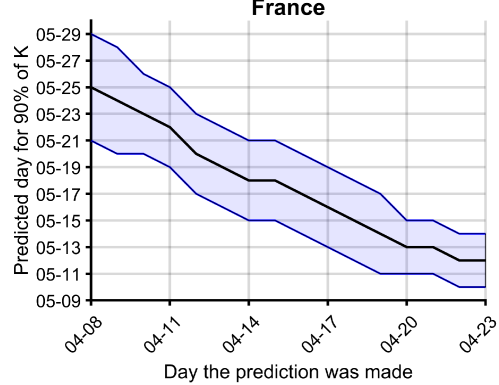
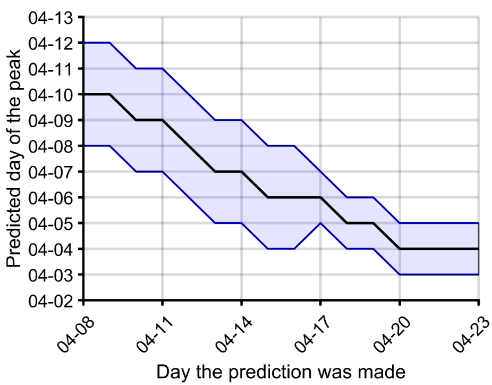
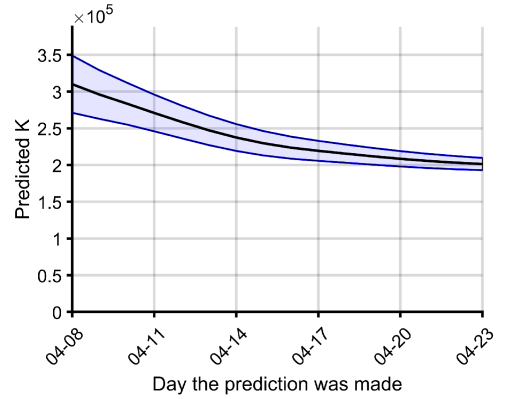
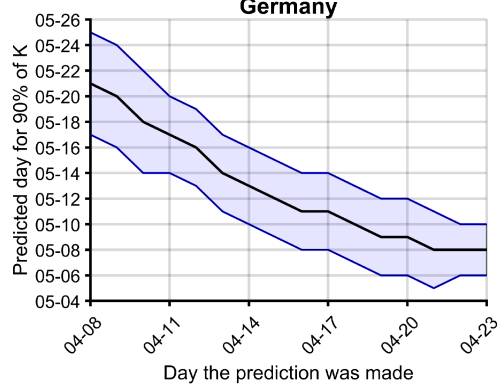
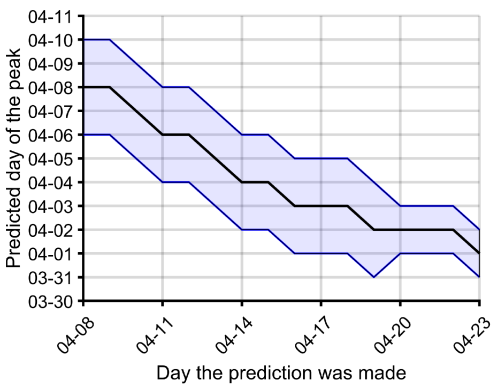
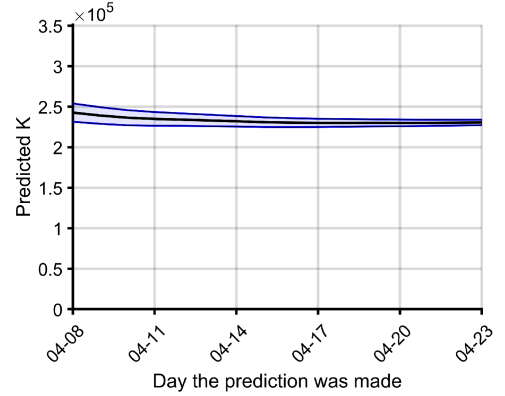
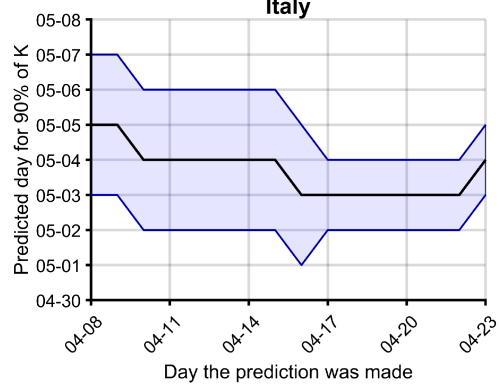
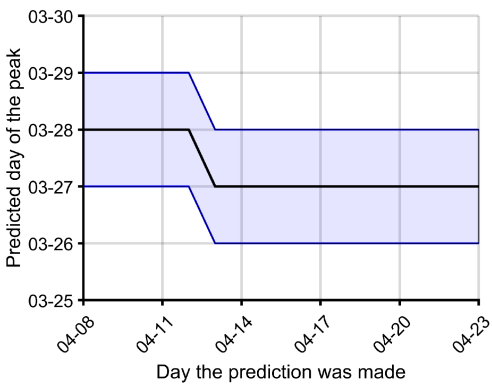
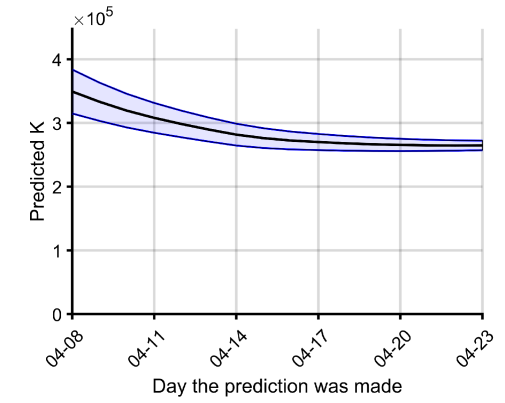
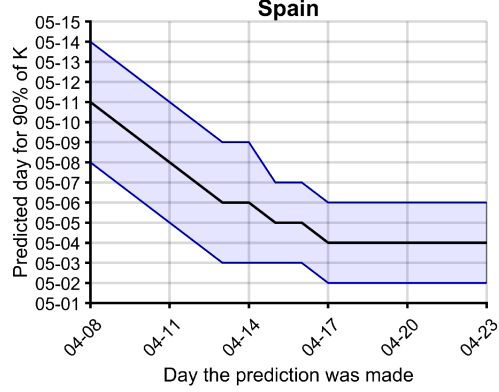
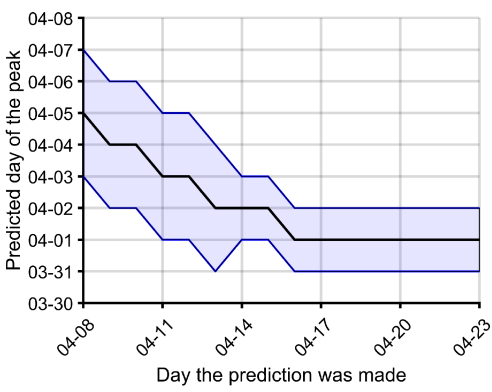
UE-EFTA-UK countries



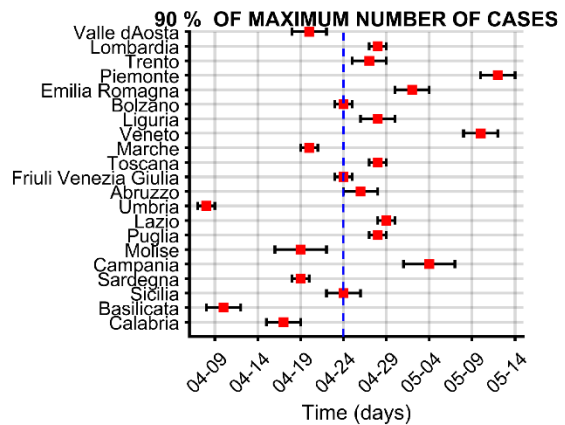
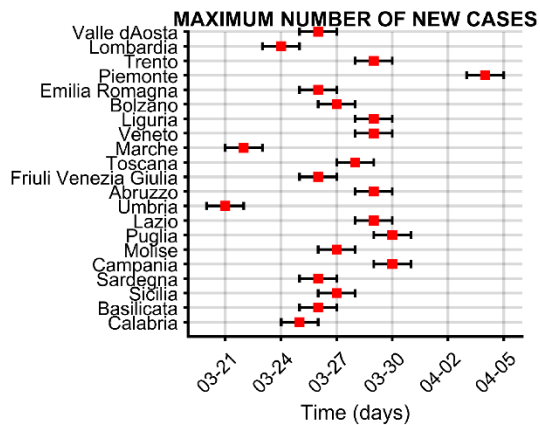
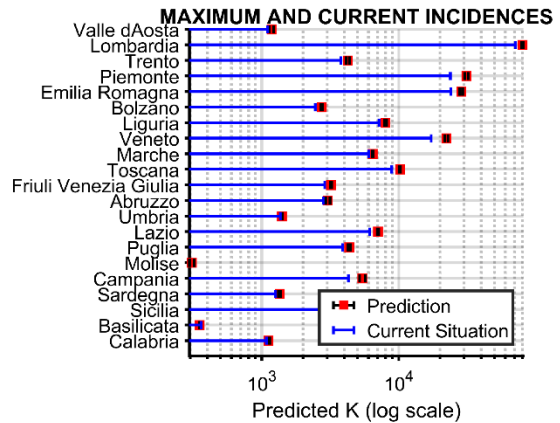
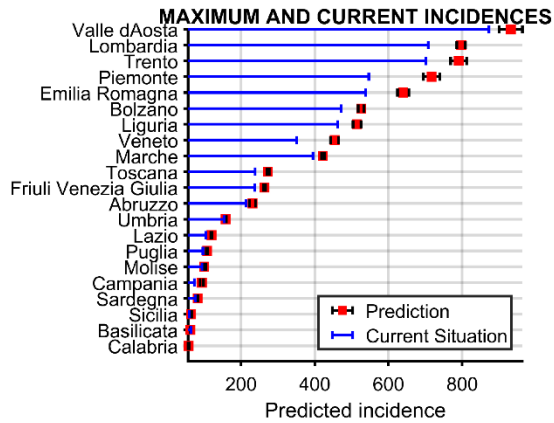
Final expected K for UE+EFTA+UK. Evolution of predicted K with time, where convergence to best estimate is seen. Last prediction is numerically shown in title.



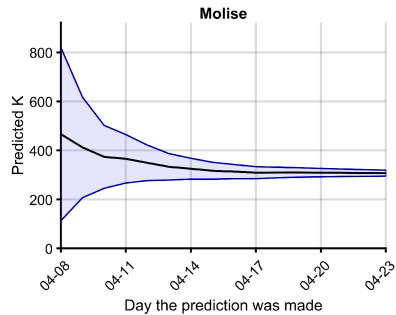
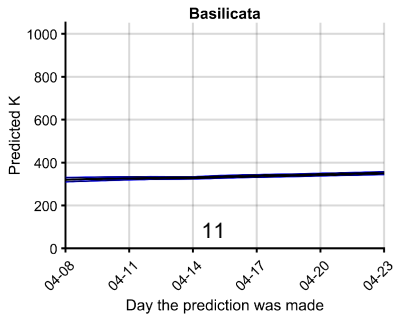
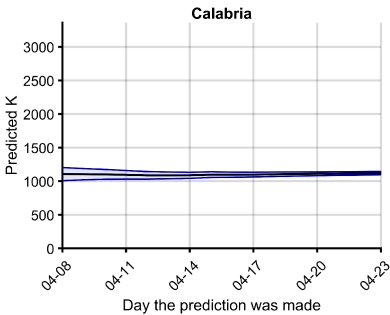
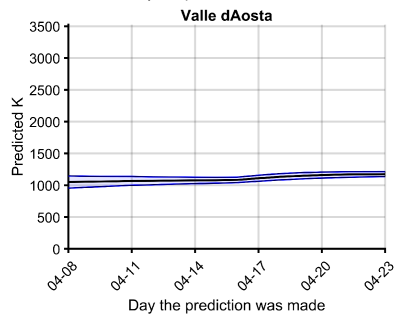
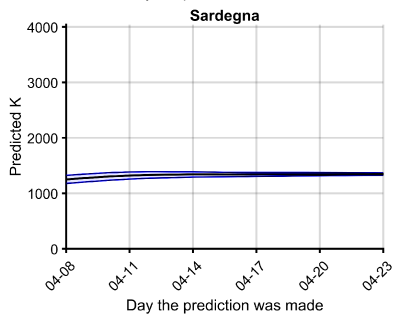
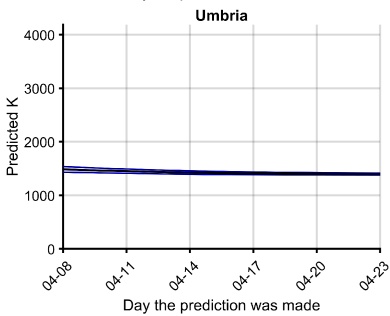
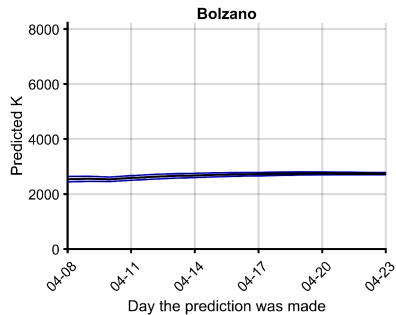
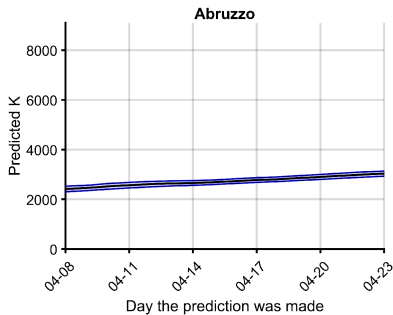
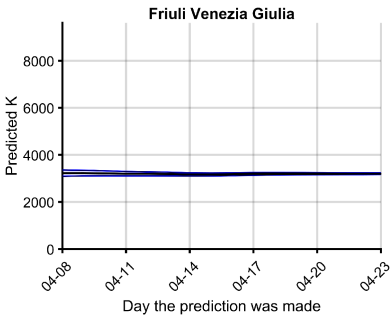
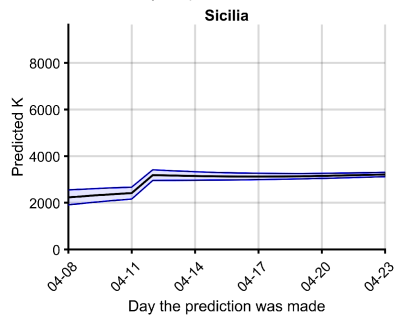
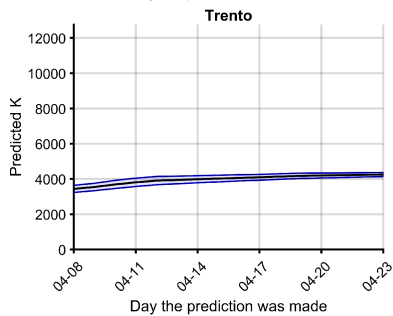
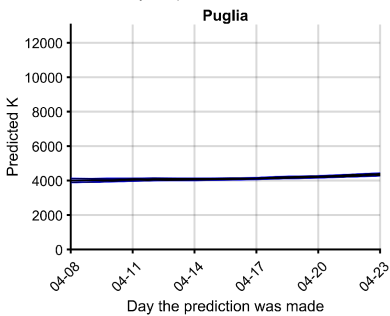
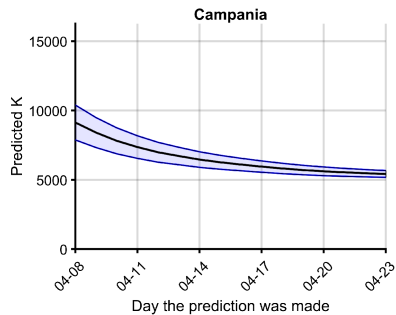
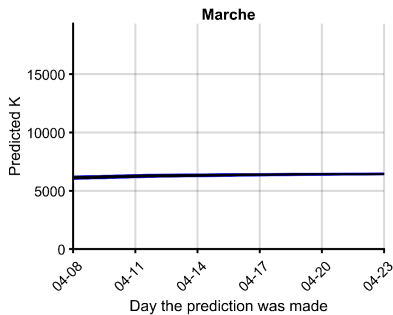
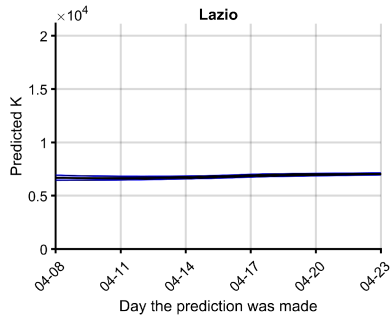
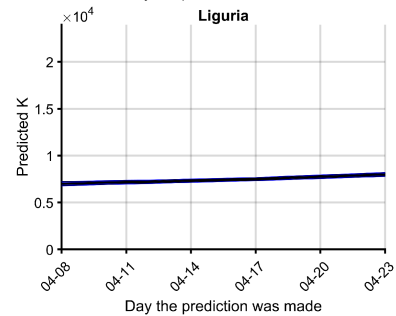
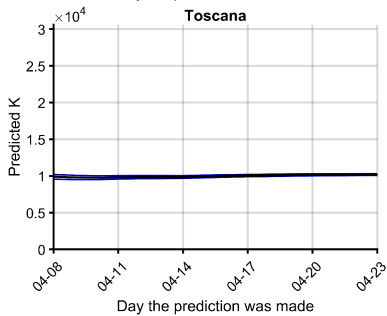
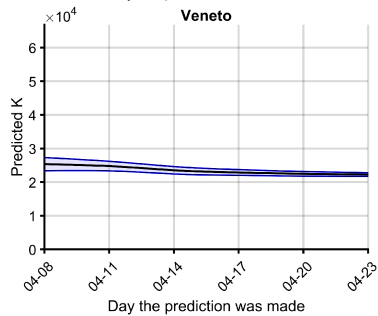
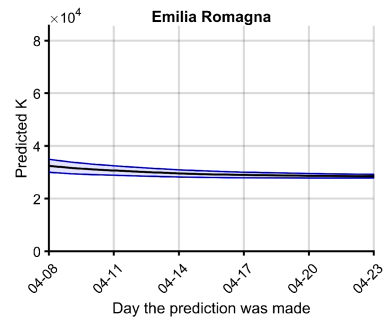
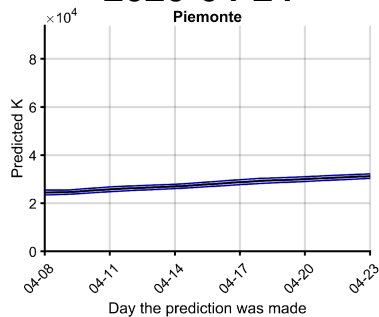
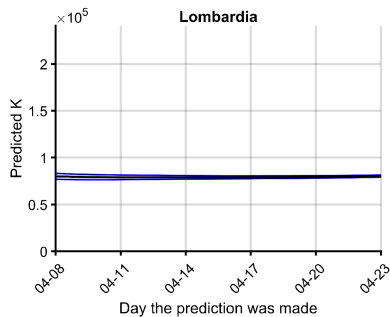
2020-04-23



Italian regions



2020-04-24



Situation and tendencies in Italian regions

Italy

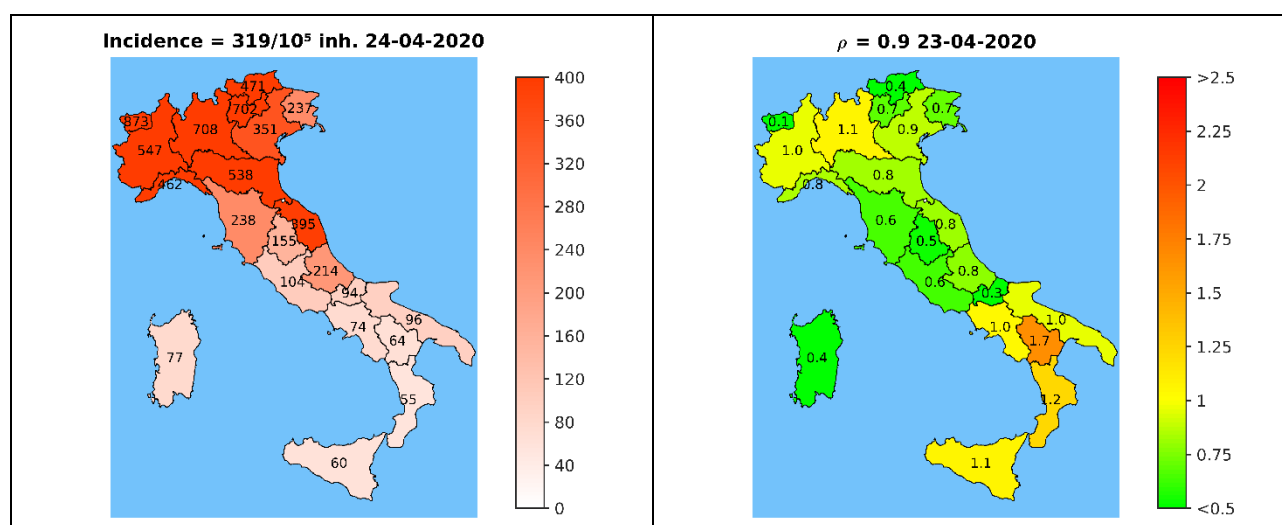
Country	Reported data						Indexes		
	Cumulative cases	Attack rate / 10 ⁵ inh.	Cumulative deaths	Mortality / 10 ⁵ inh.	Active cases (last 14 days)	14-day attack rate / 10 ⁵ inh	Mean $\rho^{(1)}$	EPG ⁽²⁾	EPG2 ⁽²⁾
Lombardia	70,165	698.7	12,940	128.9	15,363	153.0	0.97	149.1	145.3
Emilia Romagna	23,723	532.0	3,269	73.3	5,046	113.2	0.81	91.2	73.4
Piemonte	23,140	531.2	2,630	60.4	8,618	197.8	0.78	155.1	121.7
Veneto	16,881	344.1	1,206	24.6	3,948	80.5	0.84	67.7	56.9
Toscana	8,780	235.4	723	19.4	2,228	59.7	0.57	33.9	19.2
Liguria	7,049	454.6	1,047	67.5	2,029	130.8	1.04	135.8	140.9
Lazio	6,054	103.0	375	6.4	1,625	27.6	0.54	15.0	8.2
Marche	5,952	390.2	857	56.2	997	65.4	0.66	43.5	28.9
Campania	4,238	73.0	332	5.7	894	15.4	0.81	12.5	10.2
Puglia	3,839	95.3	372	9.2	1,123	27.9	1.09	30.4	33.2
Trento	3,727	347.6	382	35.6	1,019	95.0	0.74	70.4	52.2
Sicilia	2,926	58.5	213	4.3	694	13.9	1.30	18.1	23.5
Friuli Venezia Giulia	2,858	235.2	256	21.1	559	46.0	0.45	20.9	9.5
Abruzzo	2,785	212.3	280	21.3	854	65.1	1.08	70.2	75.8
Bolzano	2,435	2,266.5	261	242.9	532	495.2	0.48	239.0	115.3
Umbria	1,362	154.4	61	6.9	64	7.3	0.72	5.2	3.7
Sardegna	1,254	76.5	98	6.0	228	13.9	0.85	11.9	10.1
Valle d'Aosta	1,096	872.6	127	101.1	228	181.5	0.23	40.9	9.2
Calabria	1,069	54.9	76	3.9	195	10.0	0.64	6.5	4.2
Basilicata	356	63.2	24	4.3	53	9.4	0.68	6.4	4.4
Molise	284	92.9	20	6.5	50	16.4	1.03	16.8	17.3

Scale									
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	500.0	500.0
Best	Best	Best	Best	Best	Best	Best	0.0	0.0	0.0

⁽¹⁾ Disclaimer: parameter ρ is very sensitive and experiments daily variations. Mean ρ is averaged per 3 consecutive days, but it can still vary the following days. ⁽²⁾ EPG stands for Effective Growth Potential. It is obtained by multiplying attack rate per 10⁵ inhabitants of last 14 days (i.e. density of cases) by ρ (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG2 is a similar index but attack rate of last 14 days is multiplied by ρ^2 .

Maps of Italian regions

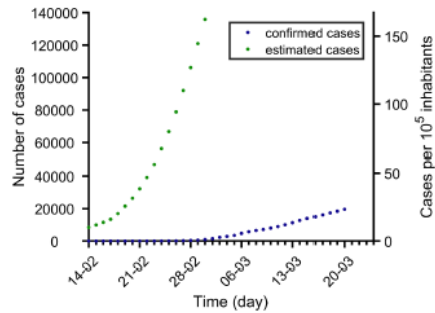
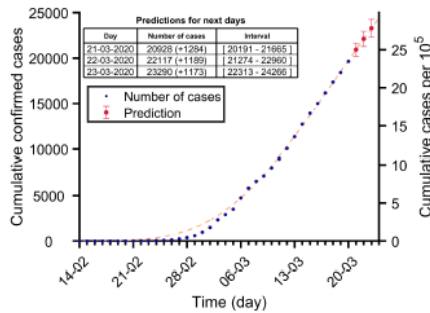
Cumulative incidence and spreading rate (ρ) in Europe, Italian regions and Spanish autonomous communities.



Legend: Countries' reports details

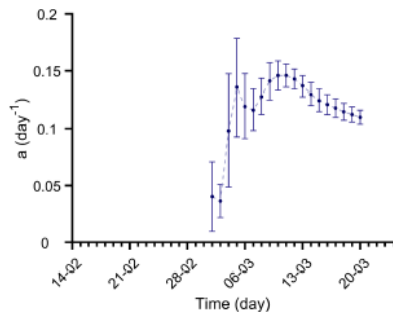
Iran 20-03-2020. Population: 83.7M. Current cumulated incidence: $23/10^5$

Confirmed cases:
data (blue),
model fitted
(dashed line),
predictions (red
points and table)

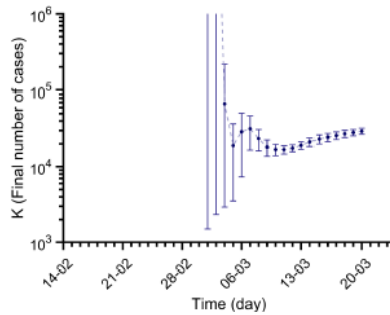


Estimated
cases using
death rate (see
Methods)

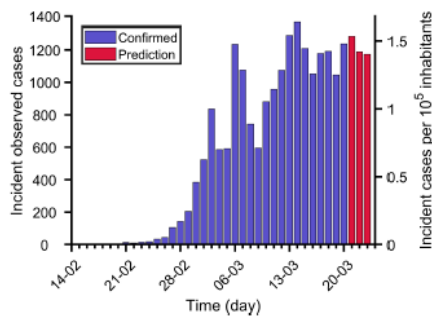
Fitted a value
using points
prior to each
date



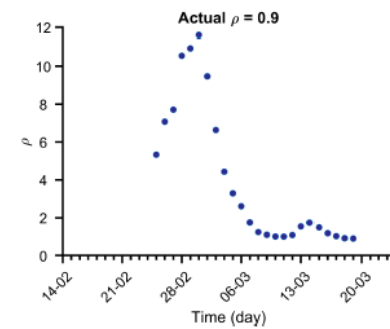
Fitted K value
using points
prior to each
date



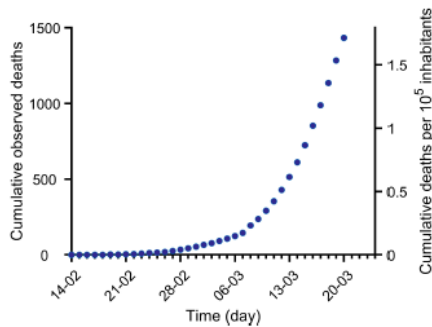
Reported
and
predicted
new cases



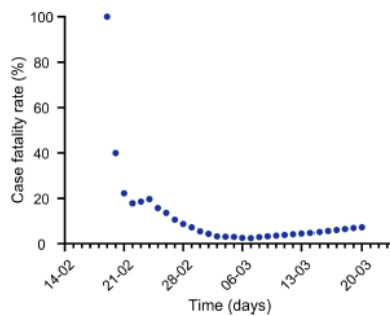
Evolution of ρ , a
parameter related
with Reproduction
number (see
Methods)



Reported
deaths

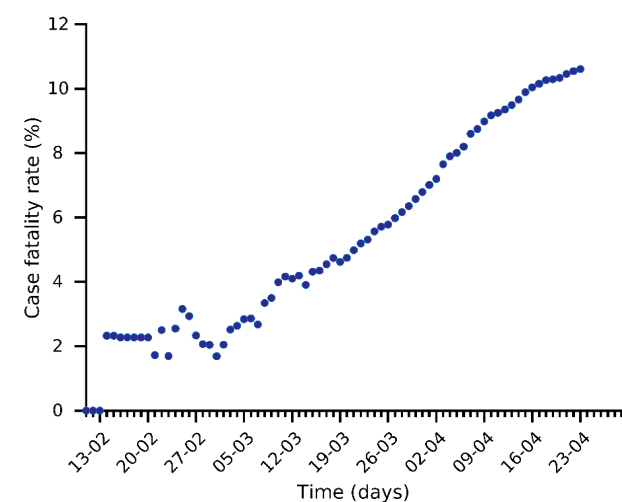
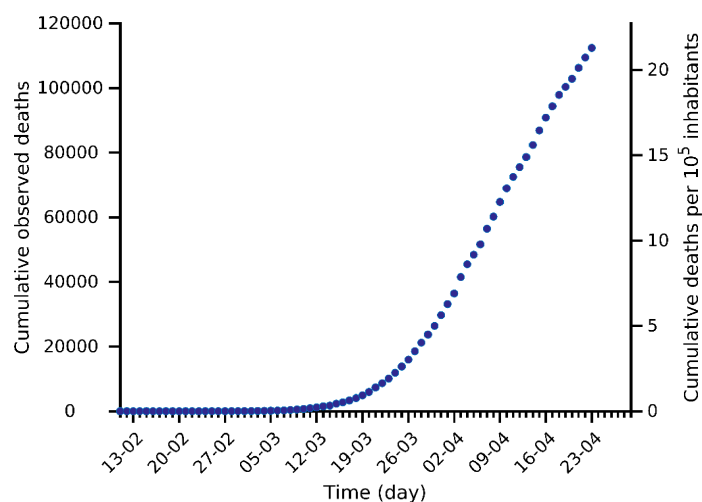
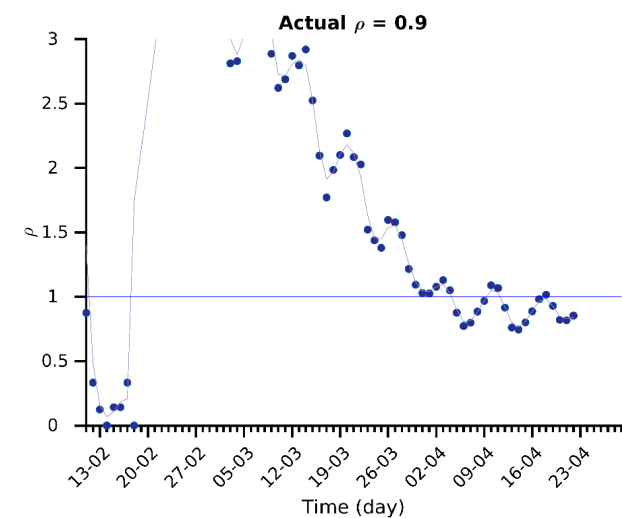
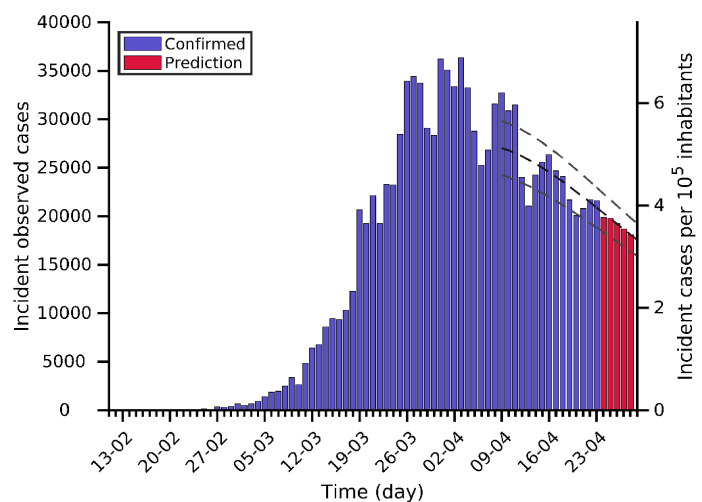
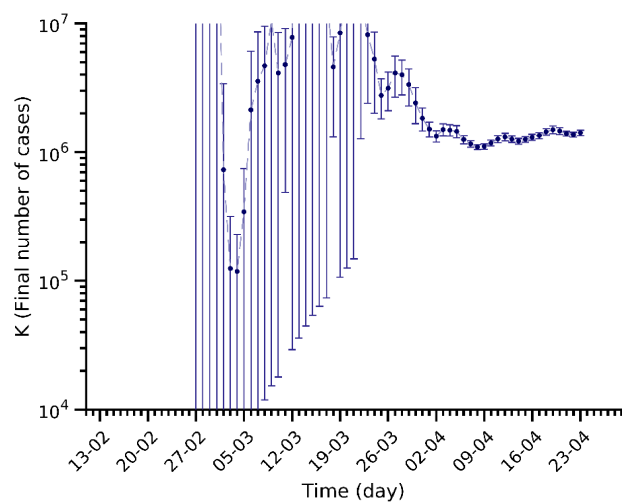
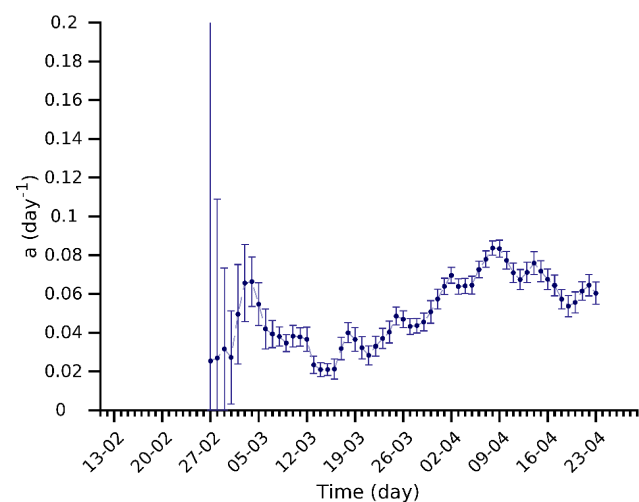
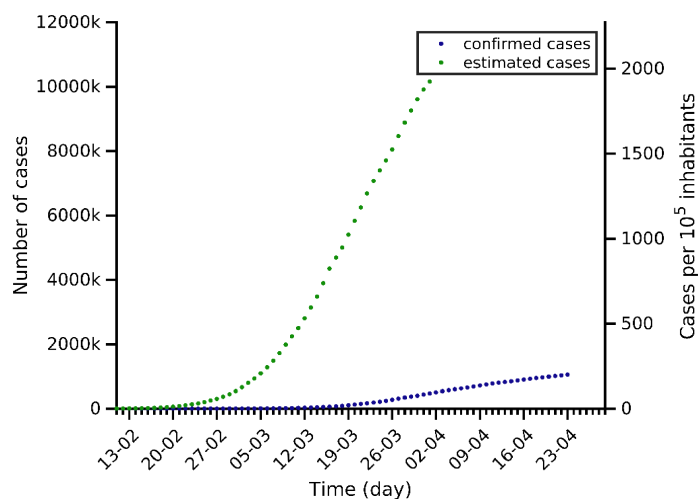
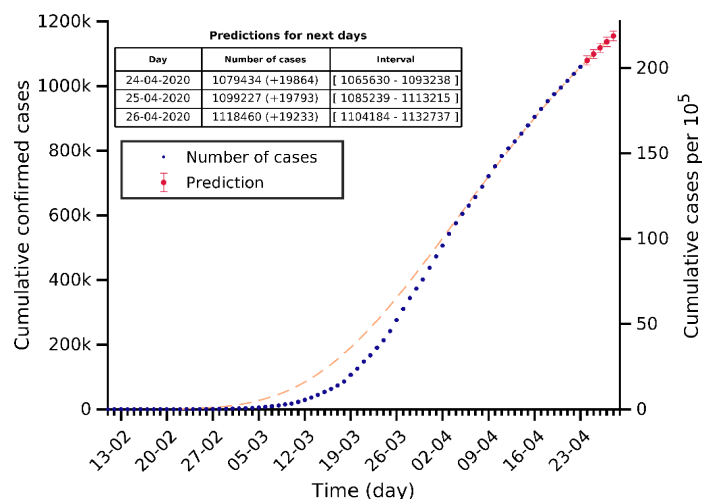


Deaths /
cumulated
reported cases

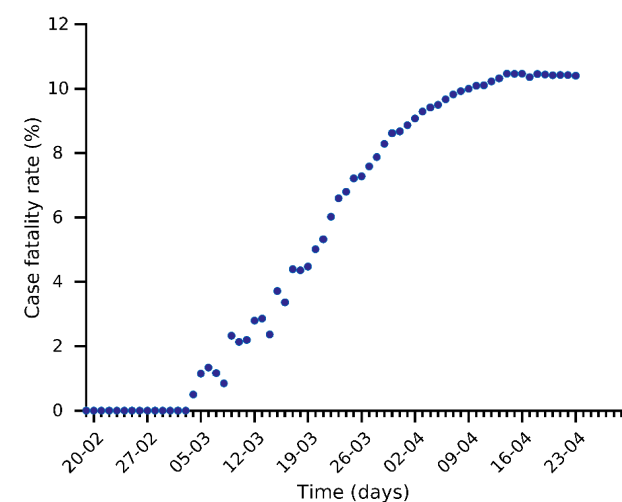
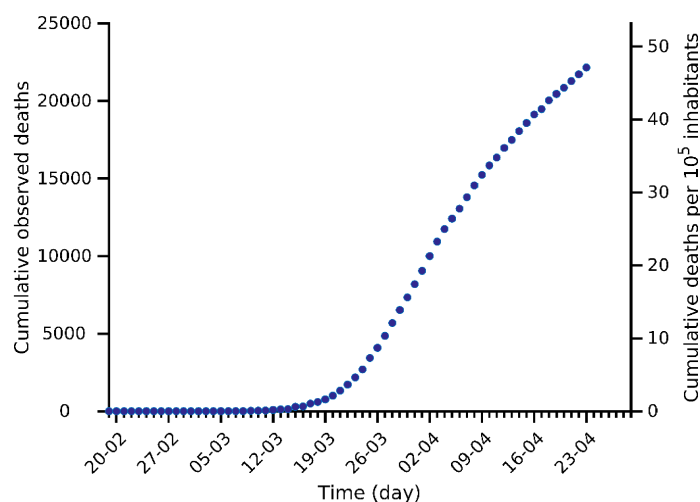
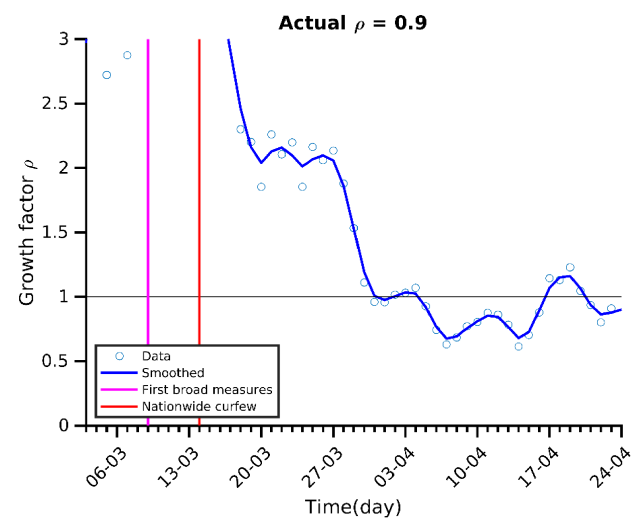
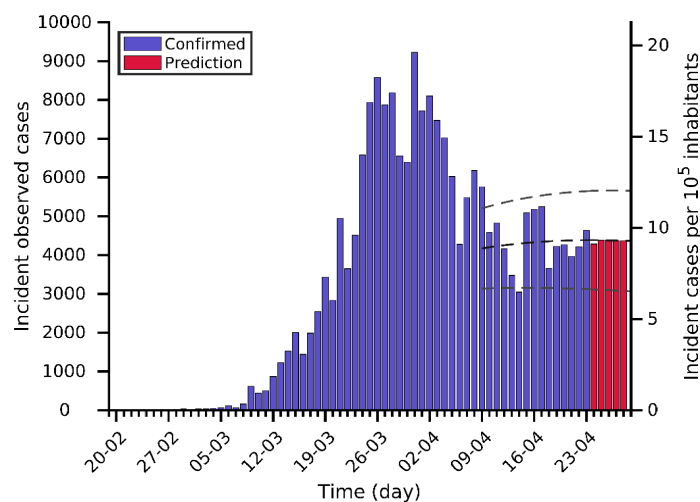
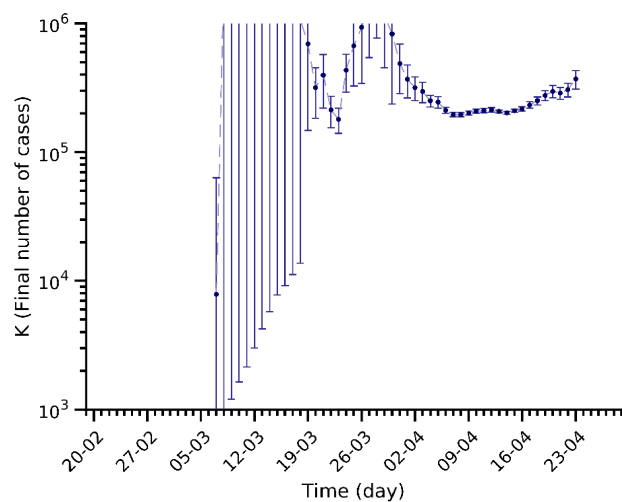
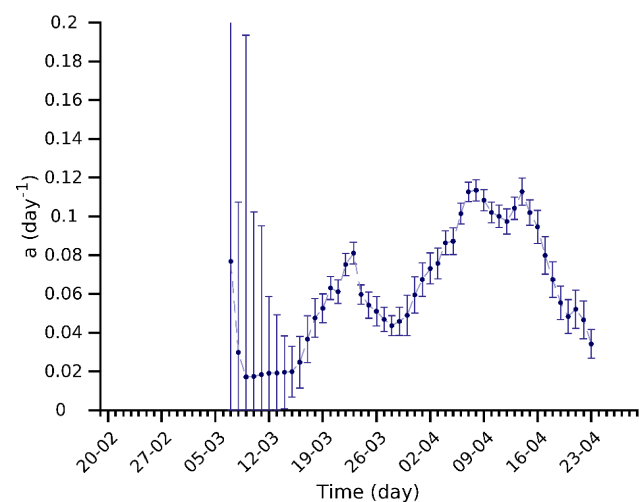
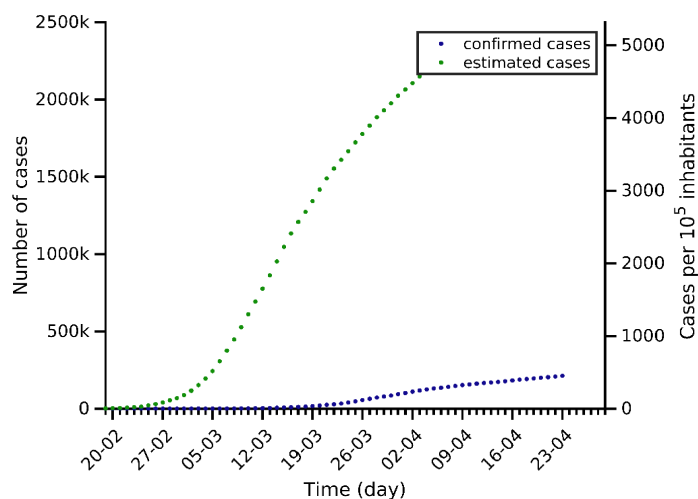
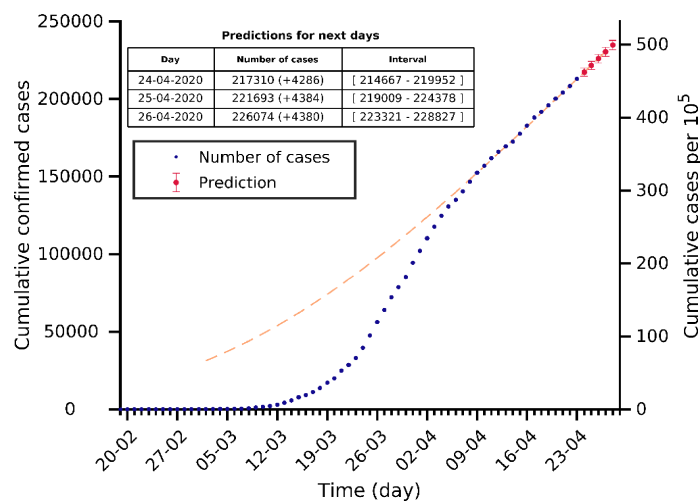


(1) Analysis and prediction of COVID-19 for EU+EFTA+UK

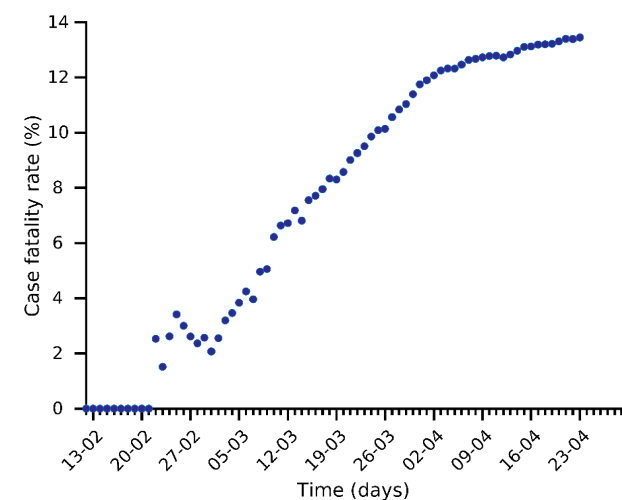
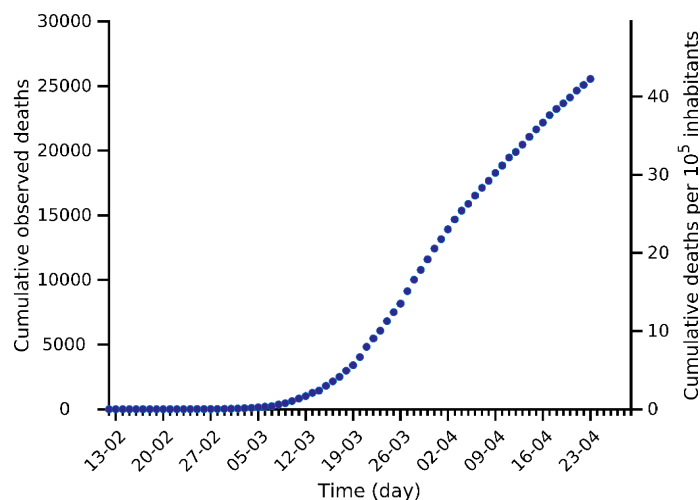
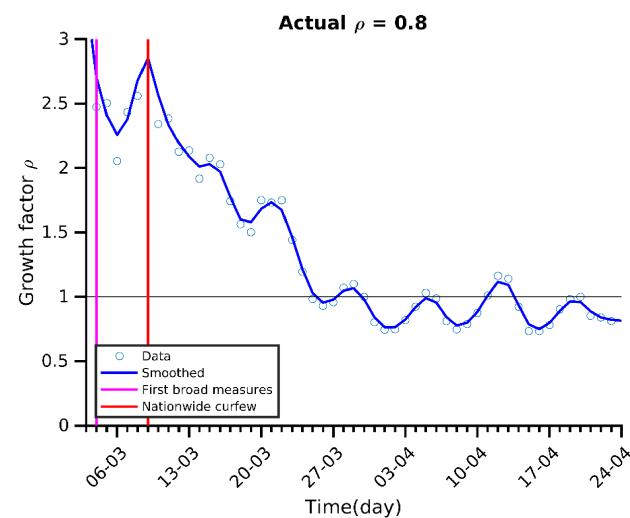
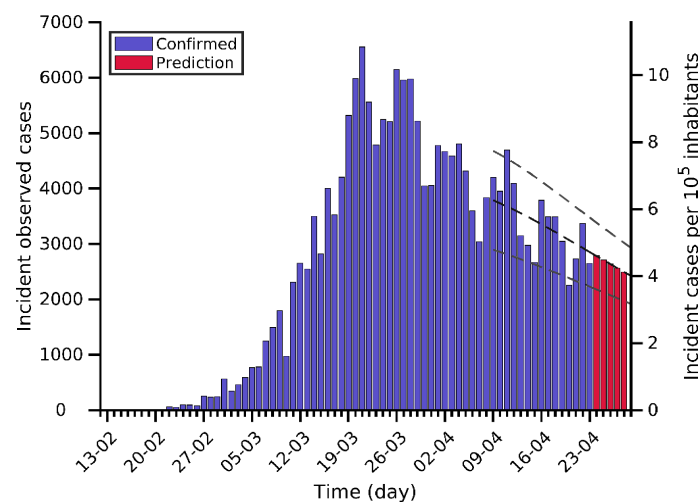
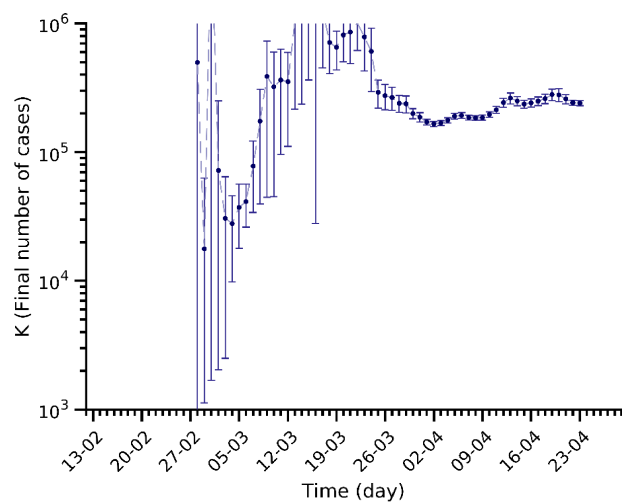
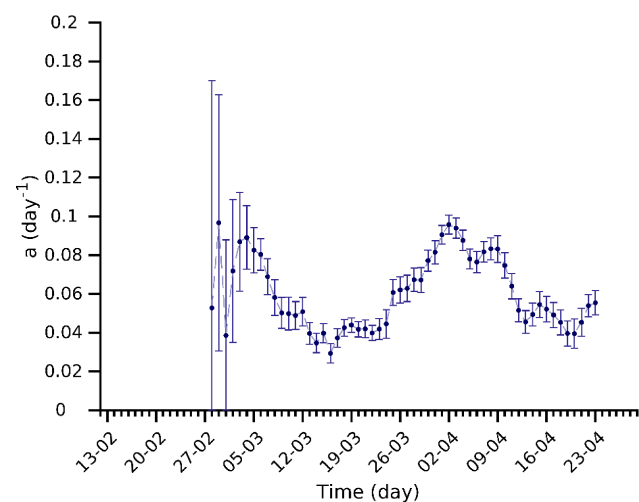
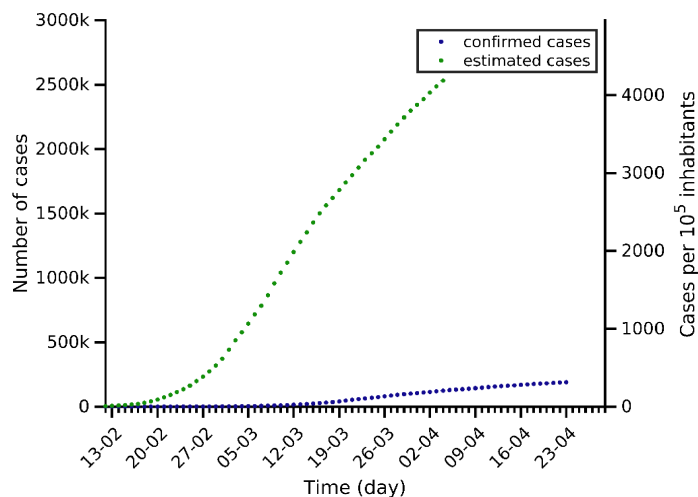
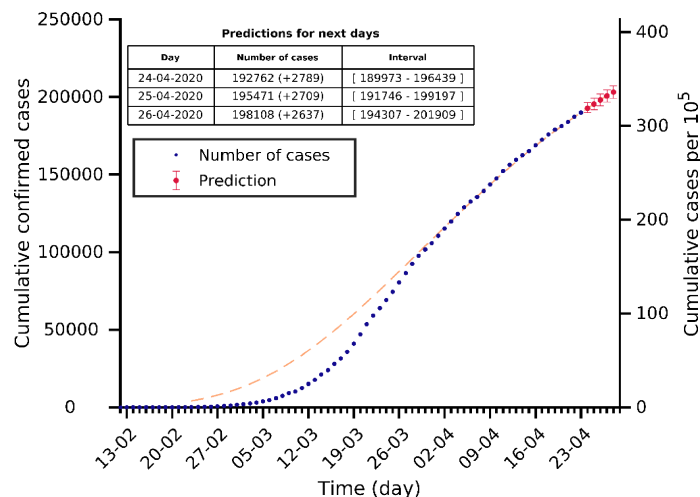
Data obtained from <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>
<https://github.com/pcm-dpc/COVID-19/tree/master/dati-andamento-nazionale> (Italy)



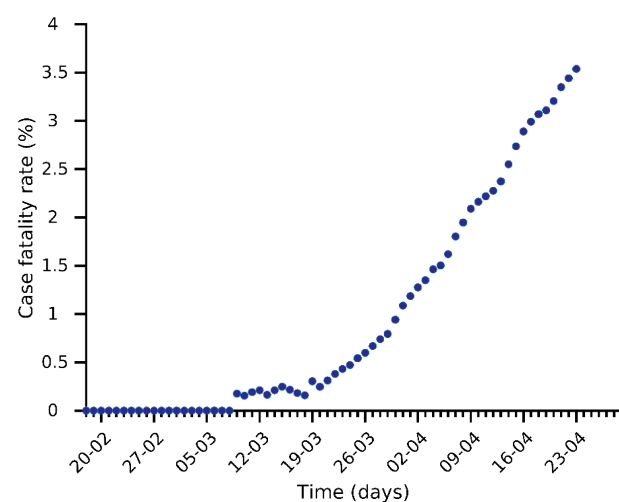
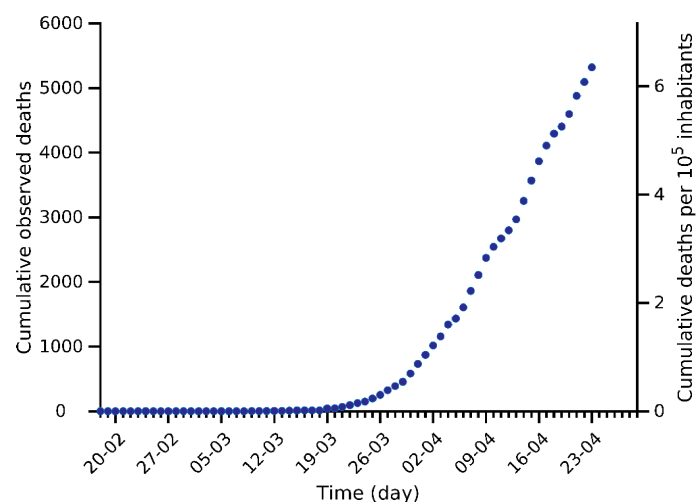
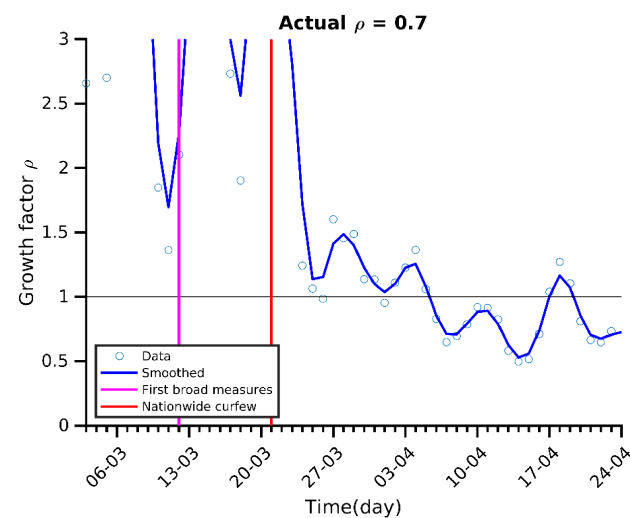
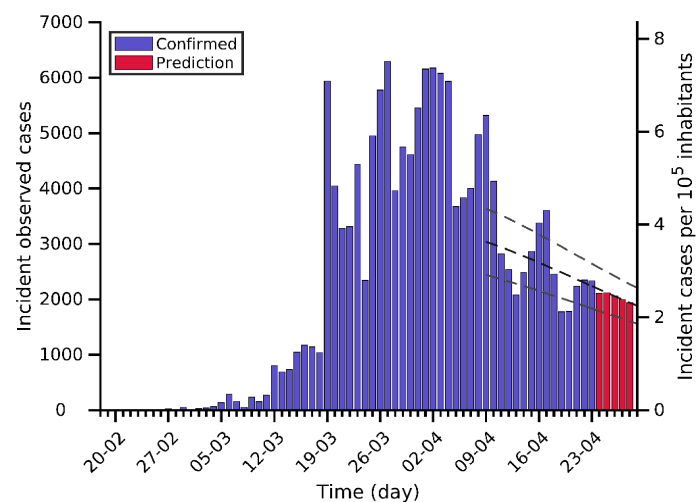
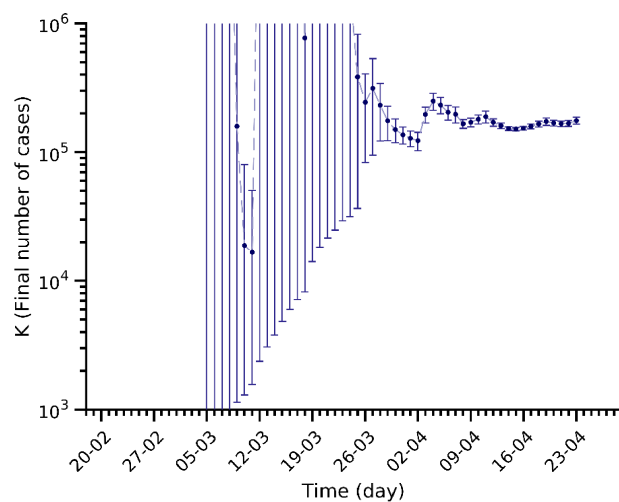
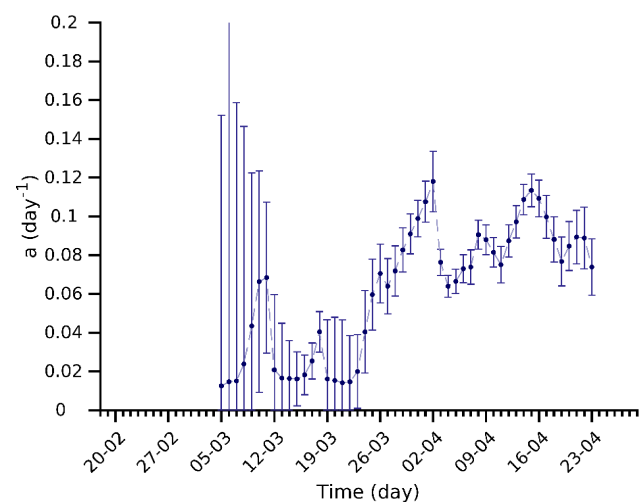
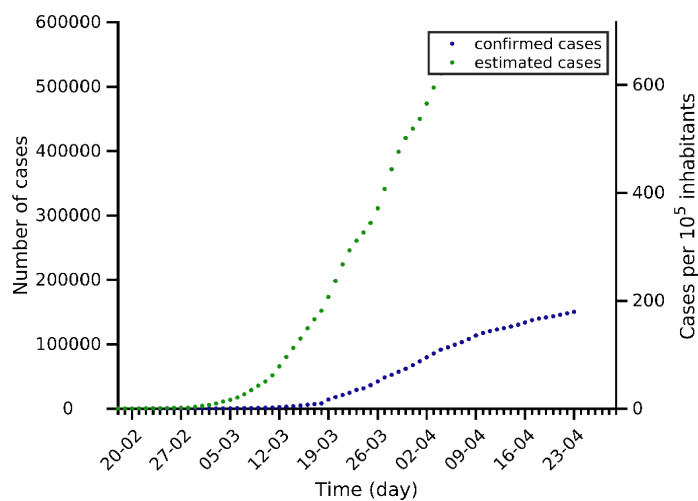
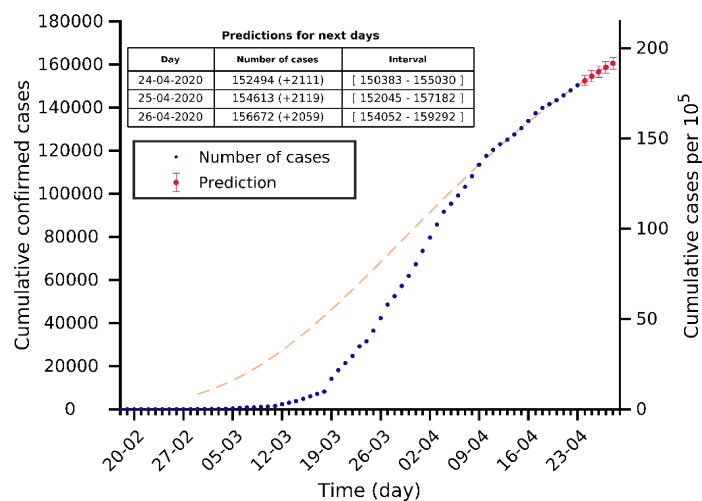
Spain 23-04-2020. Population: 47.0M. Current cumulated incidence: 453/10⁵



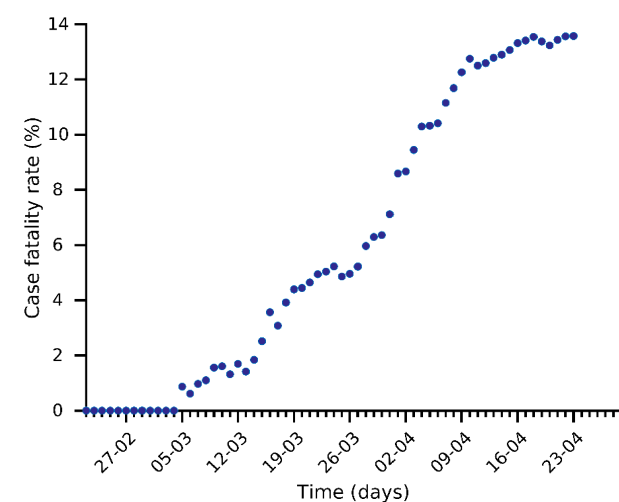
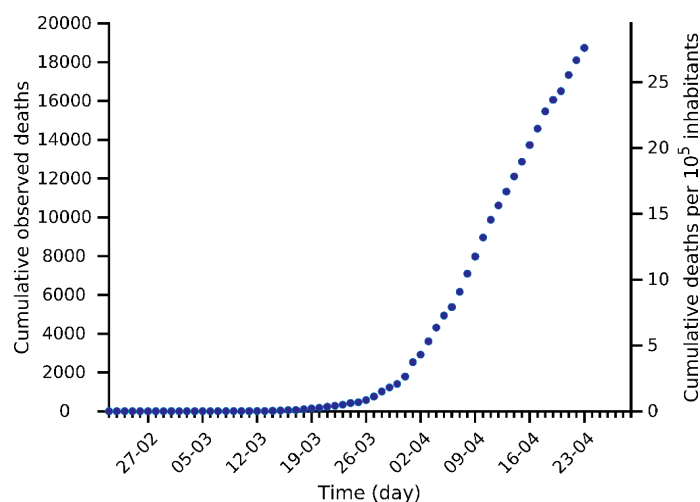
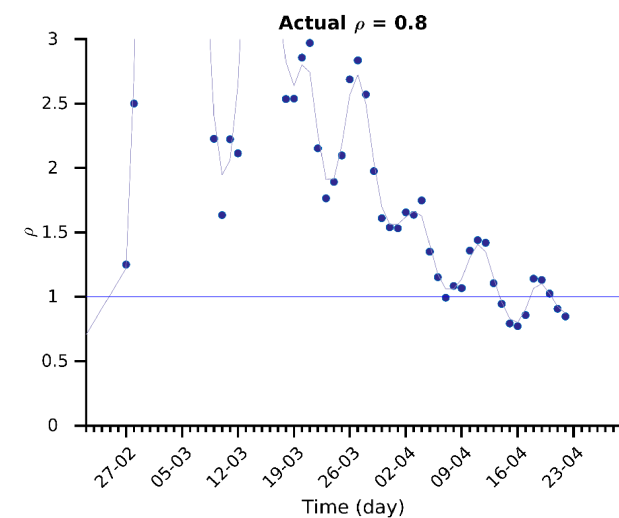
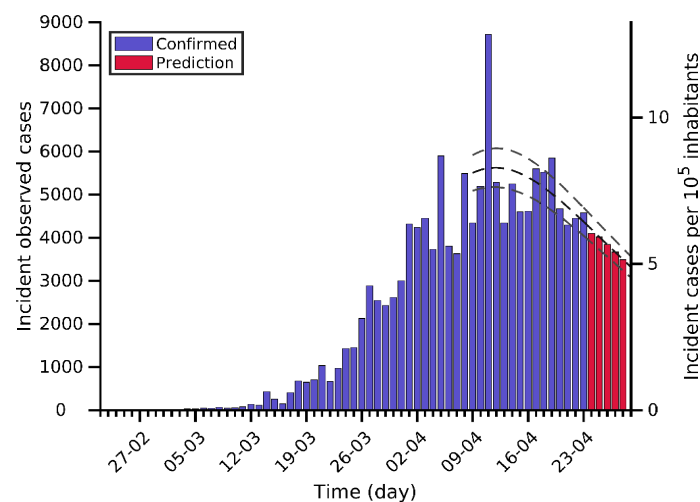
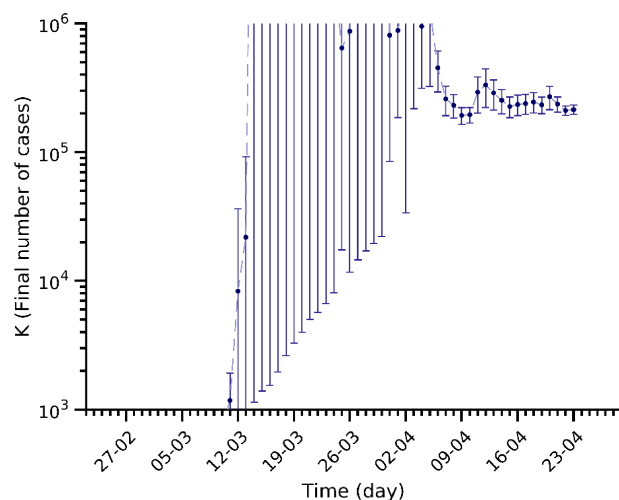
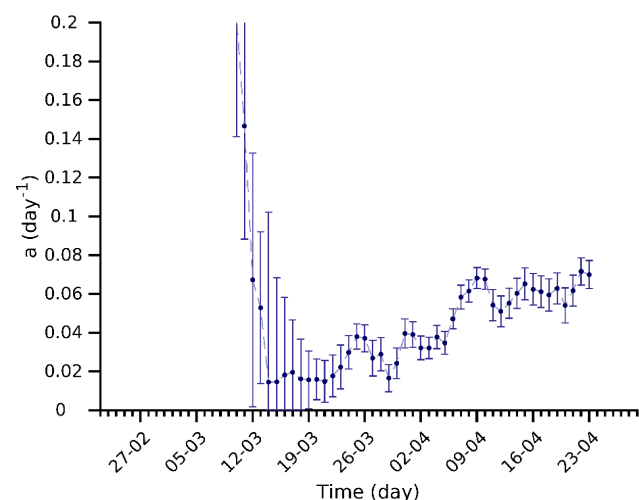
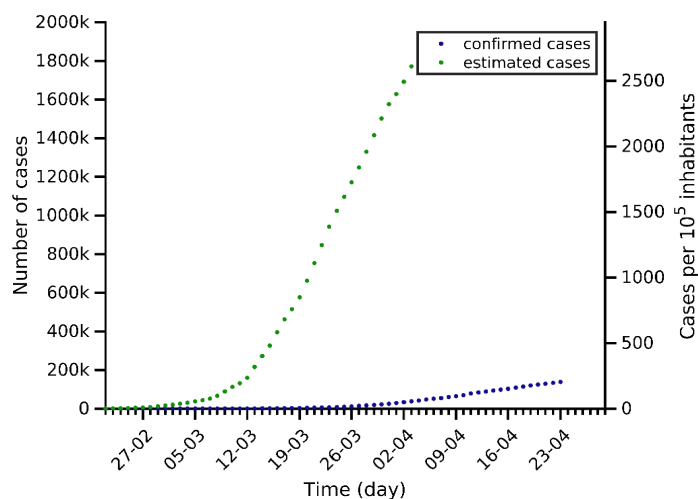
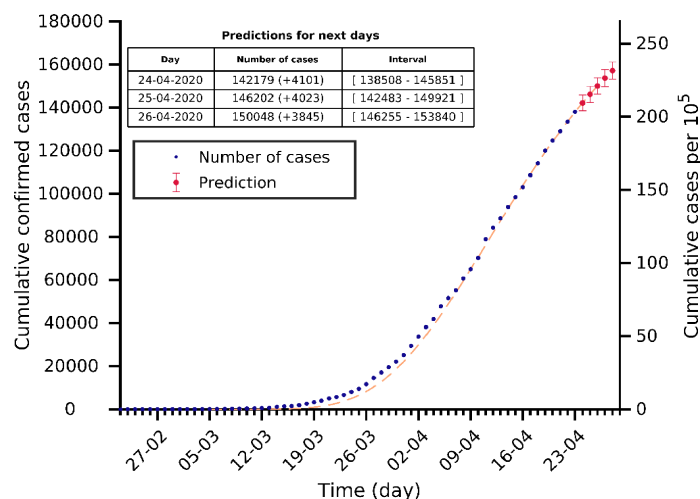
Italy 23-04-2020. Population: 60.5M. Current cumulated incidence: 314/10⁵



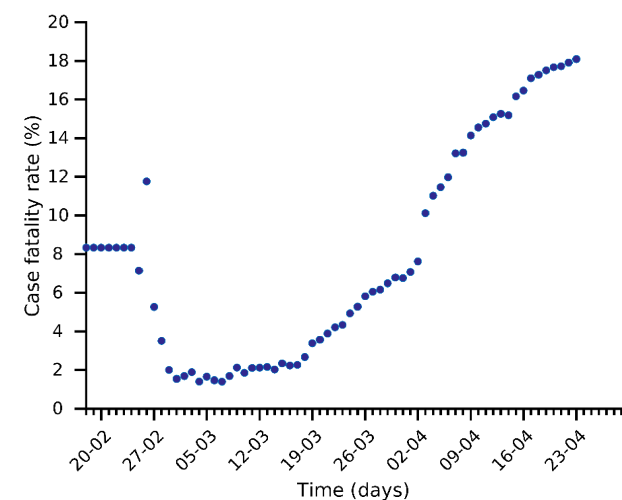
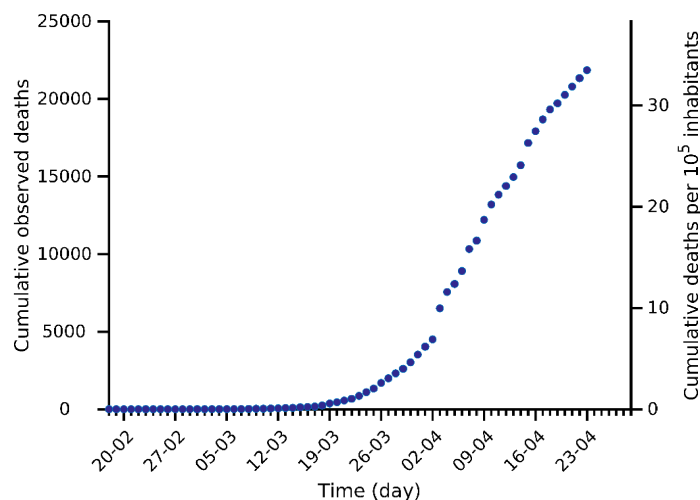
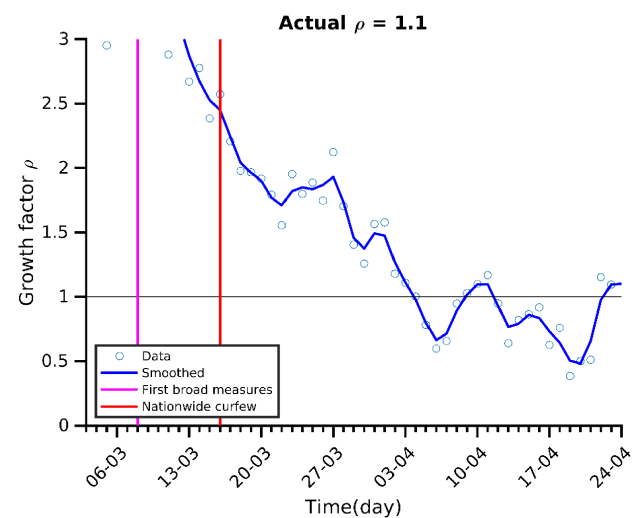
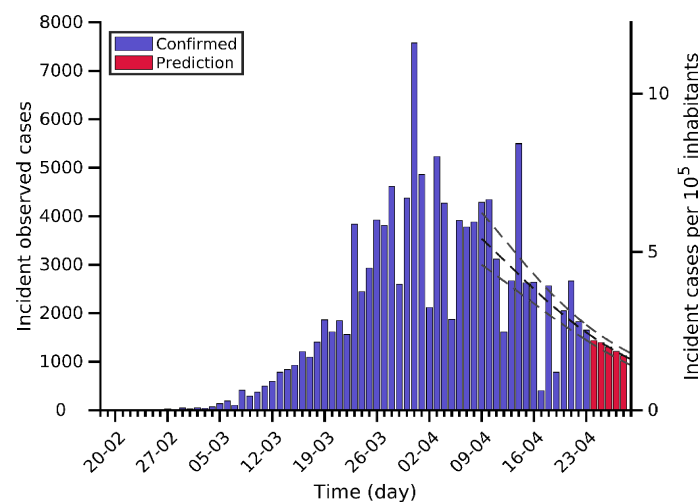
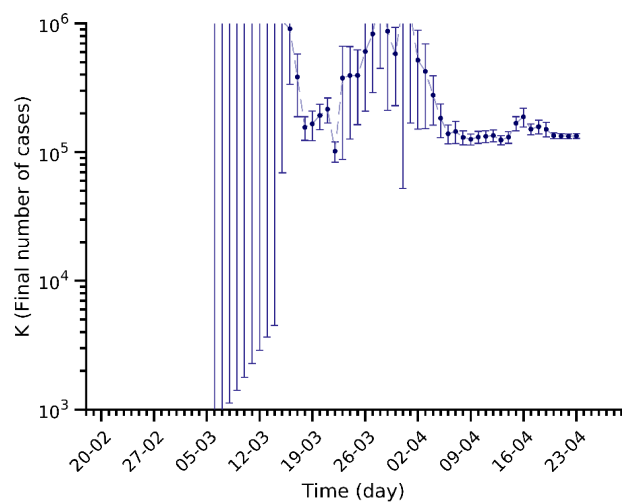
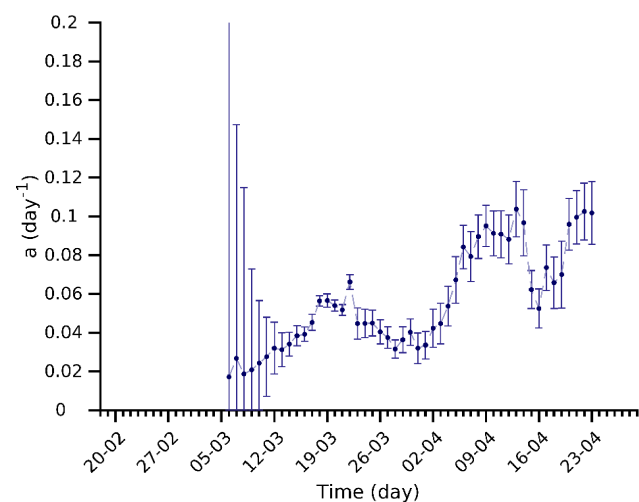
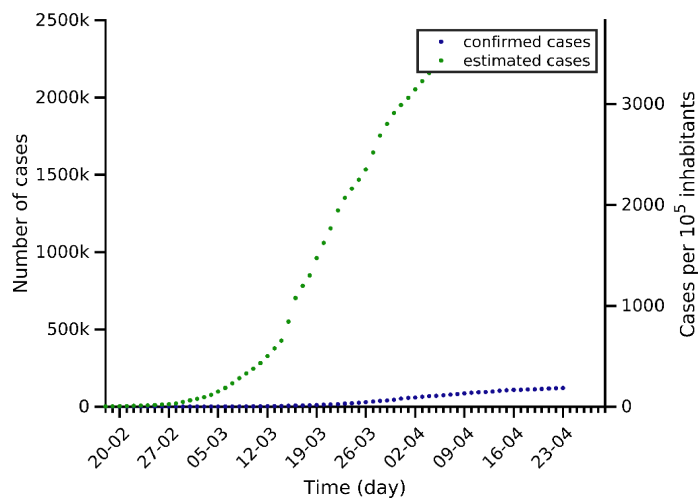
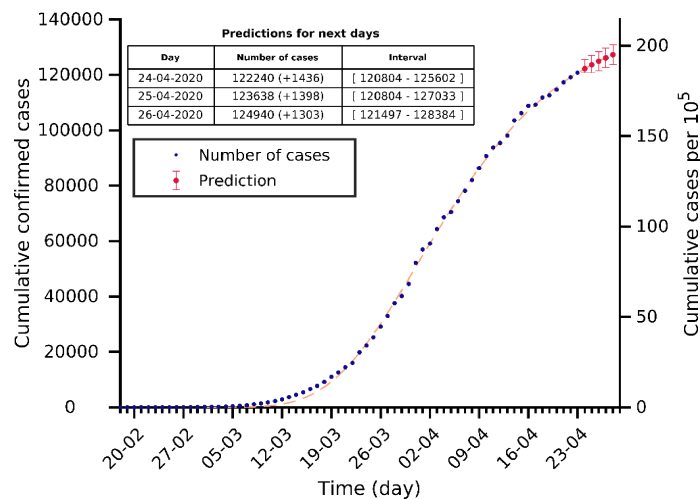
Germany 23-04-2020. Population: 83.8M. Current cumulated incidence: 179/10⁵



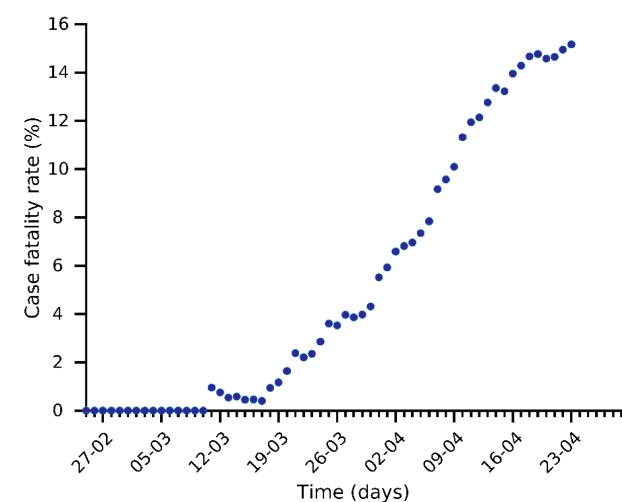
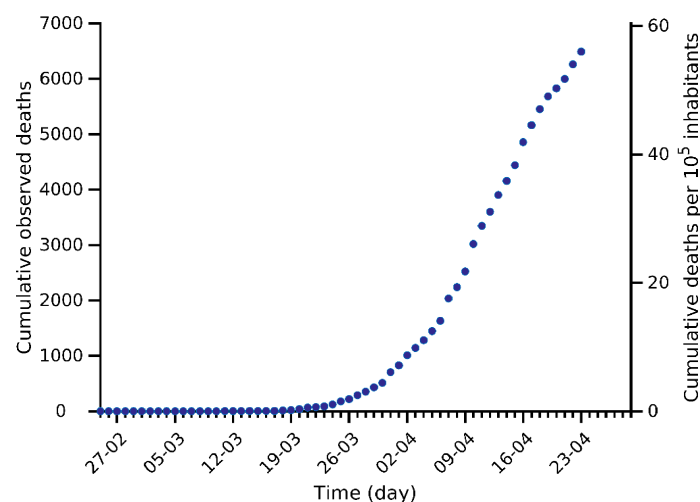
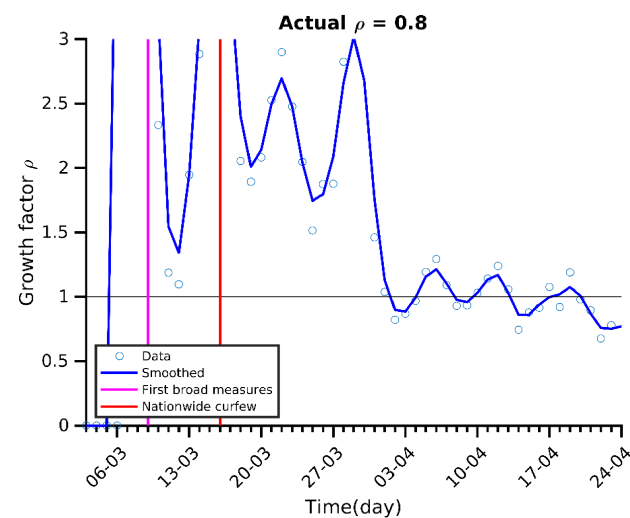
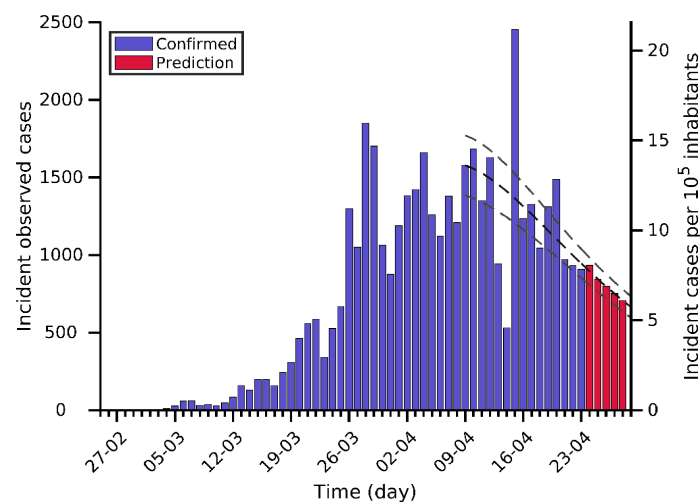
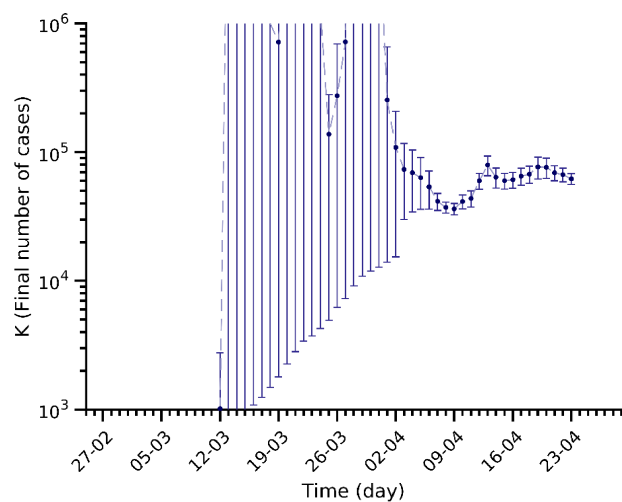
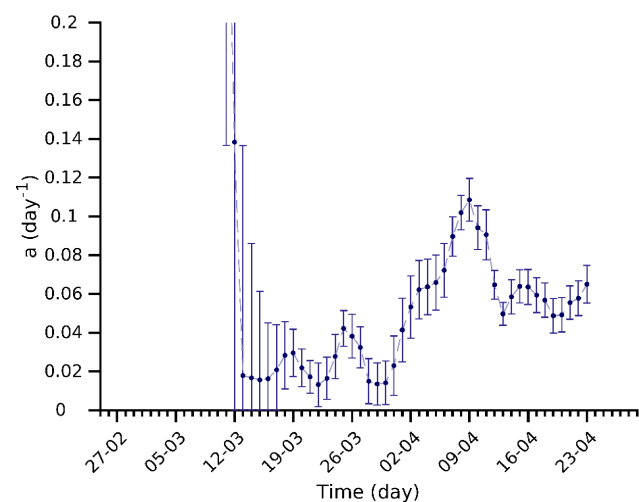
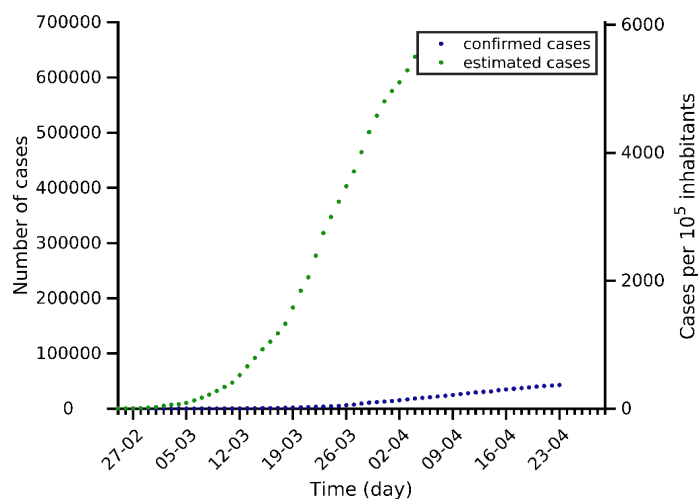
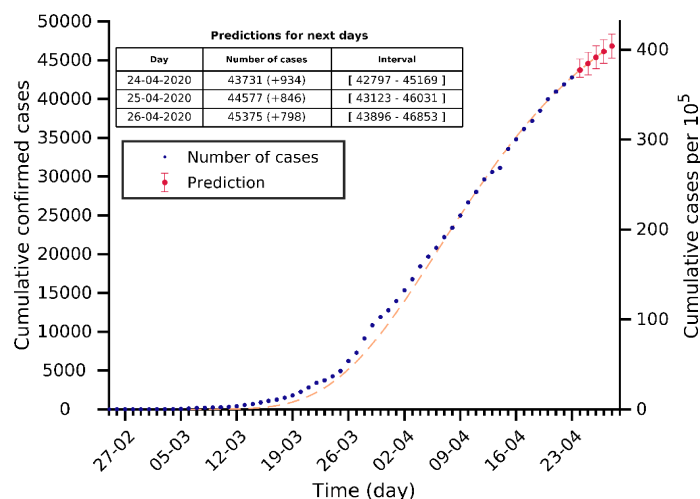
UK 23-04-2020. Population: 67.9M. Current cumulated incidence: 203/10⁵



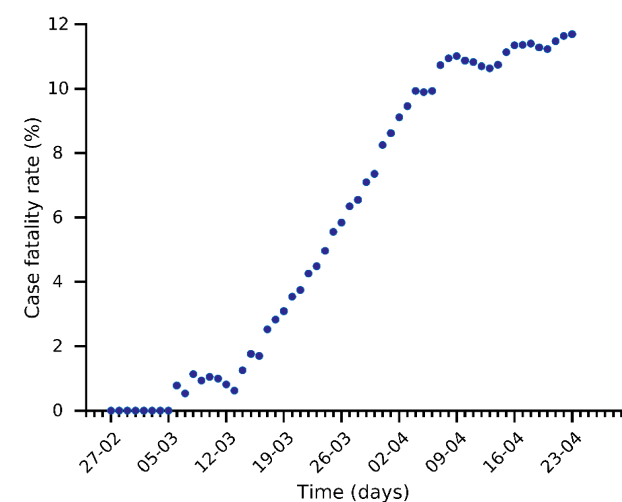
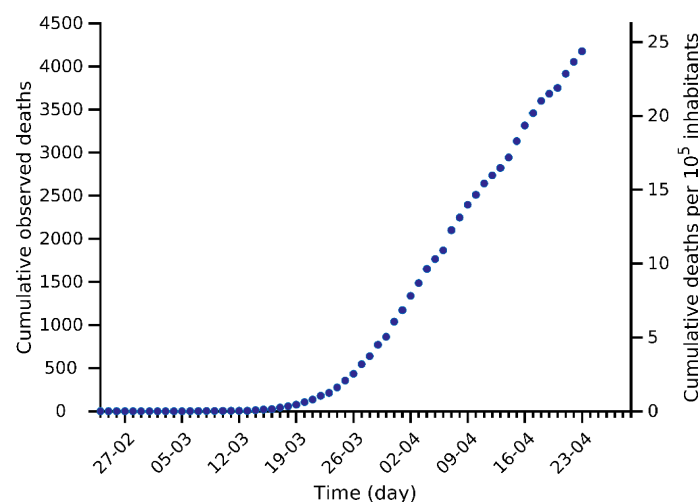
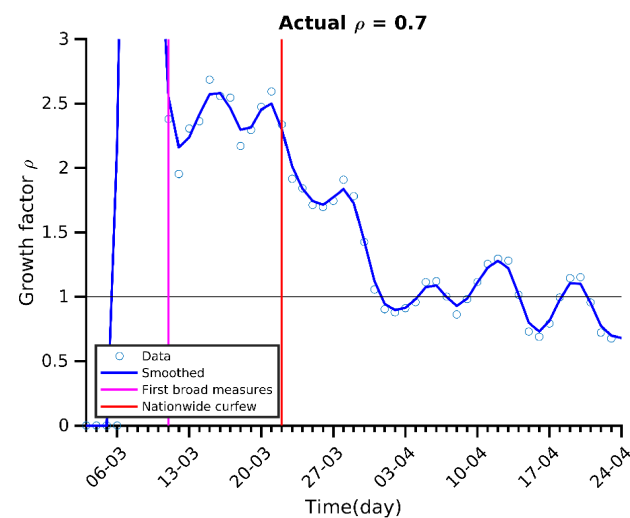
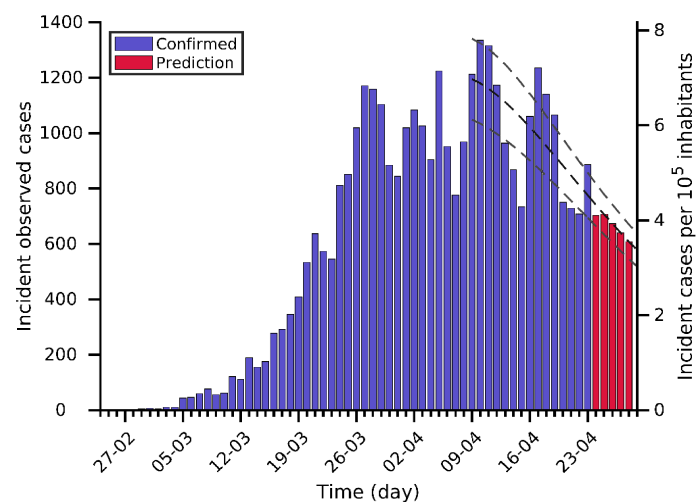
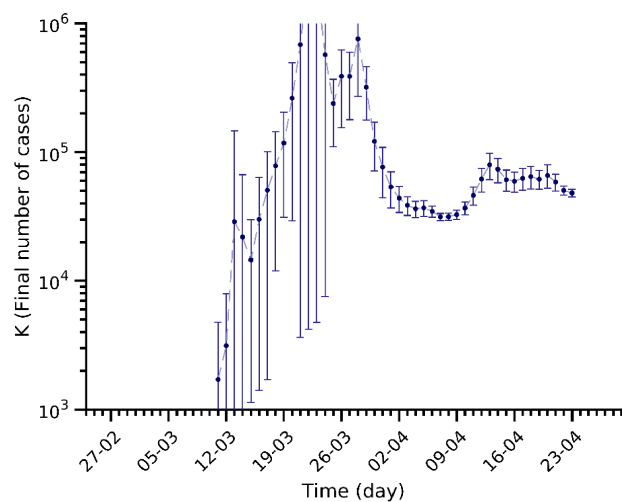
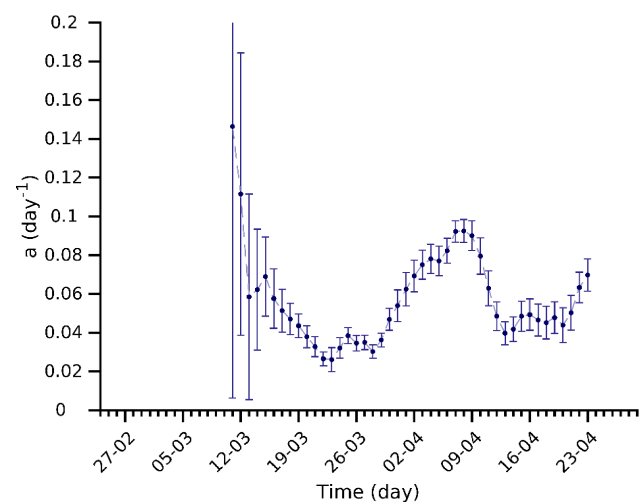
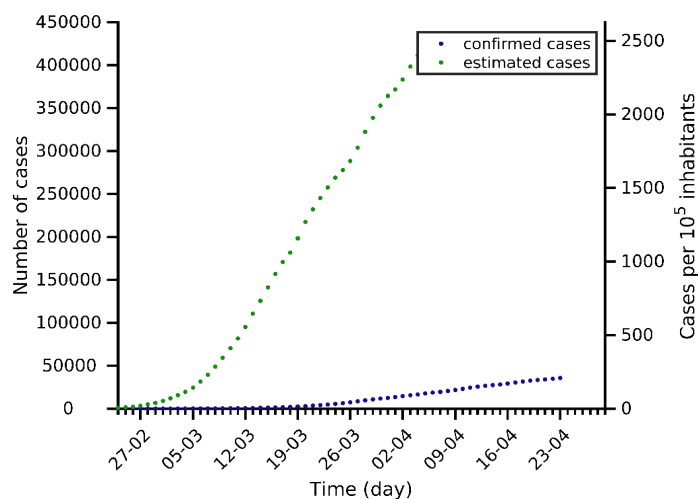
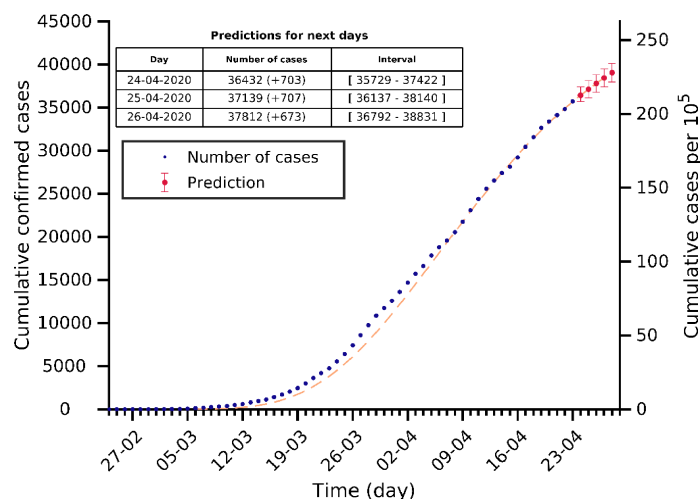
France 23-04-2020. Population: 65.3M. Current cumulated incidence: 185/10⁵



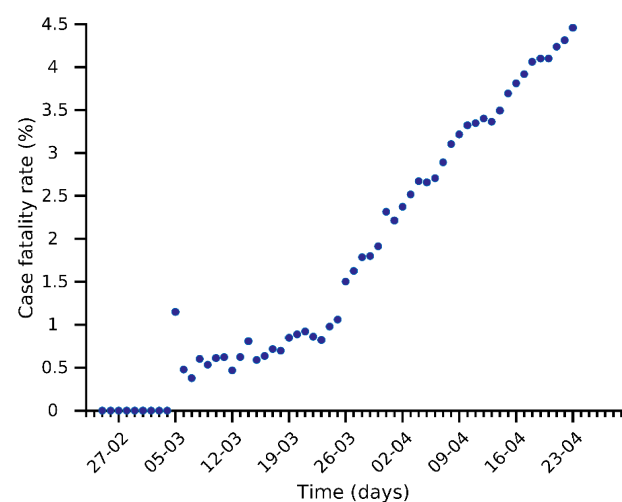
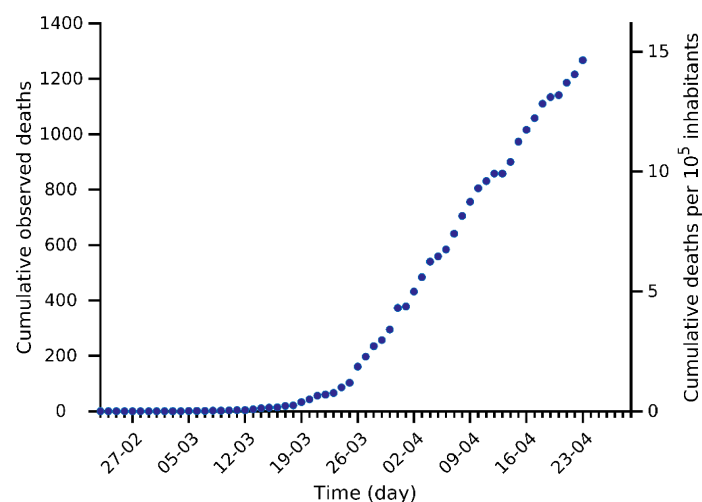
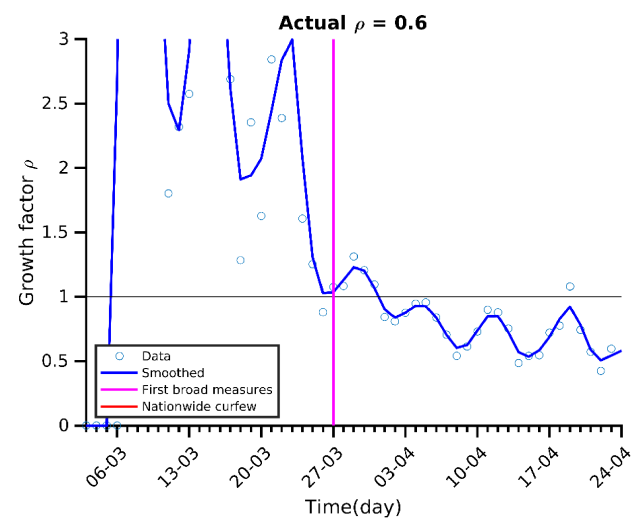
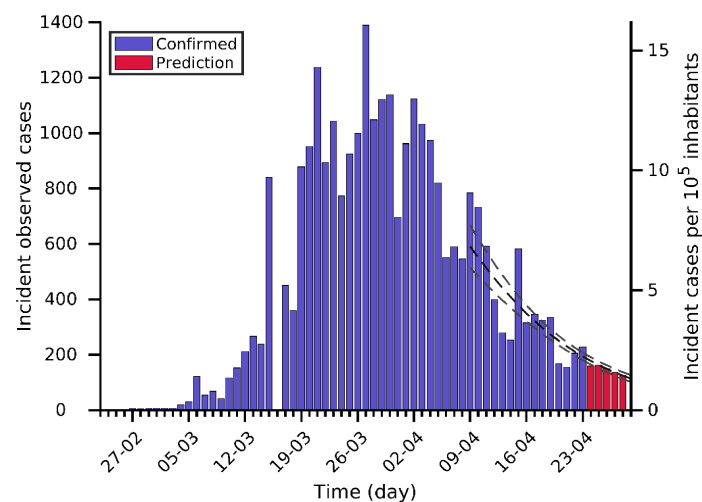
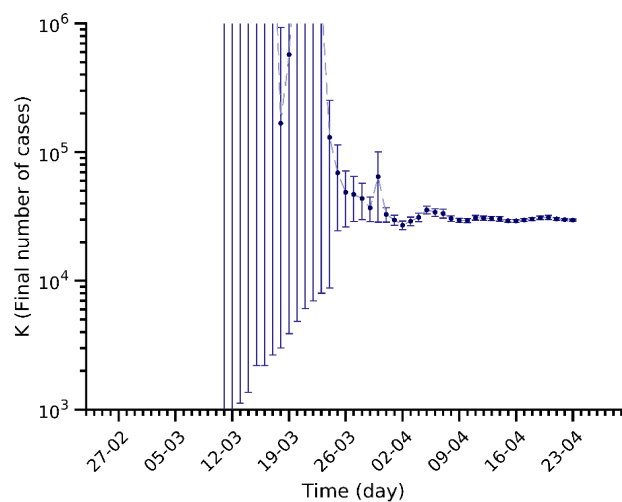
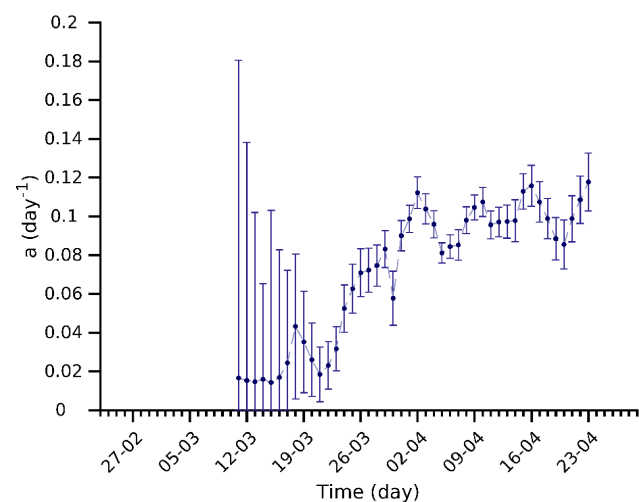
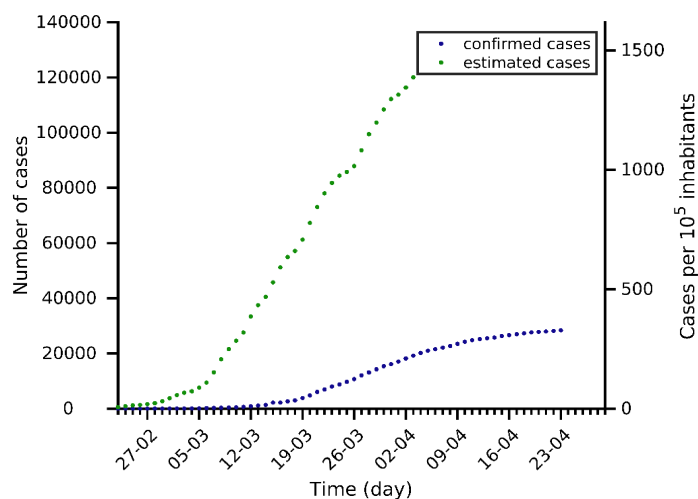
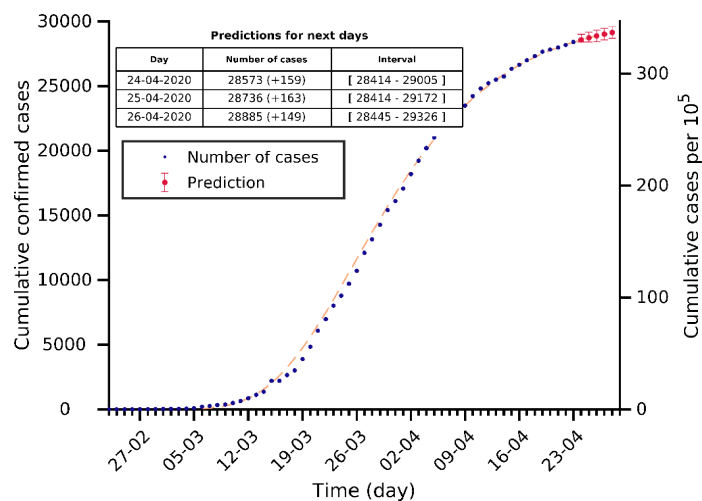
Belgium 23-04-2020. Population: 11.6M. Current cumulated incidence: 369/10⁵



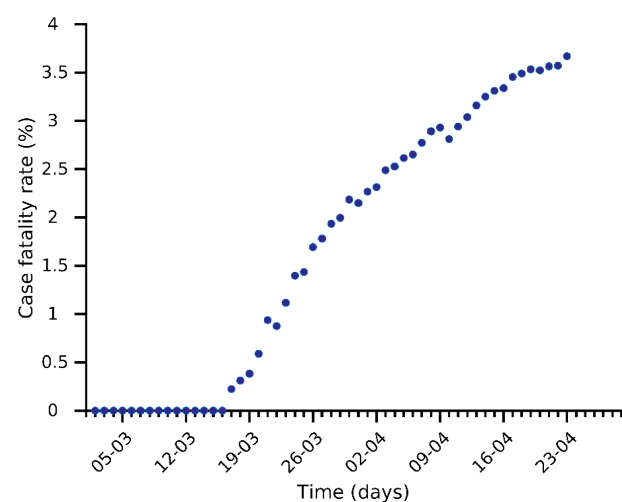
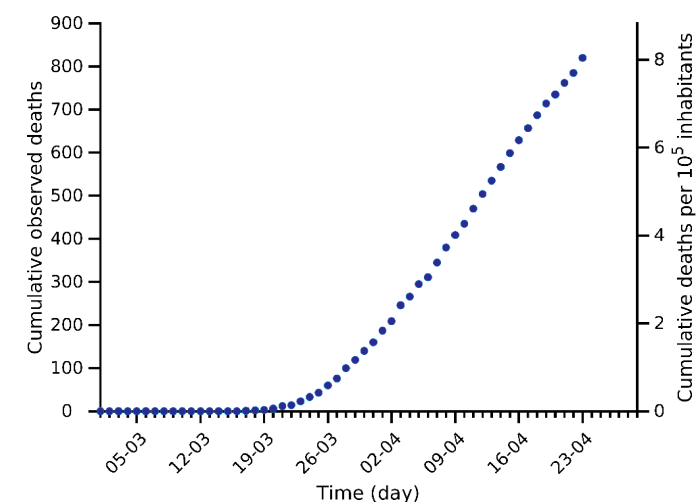
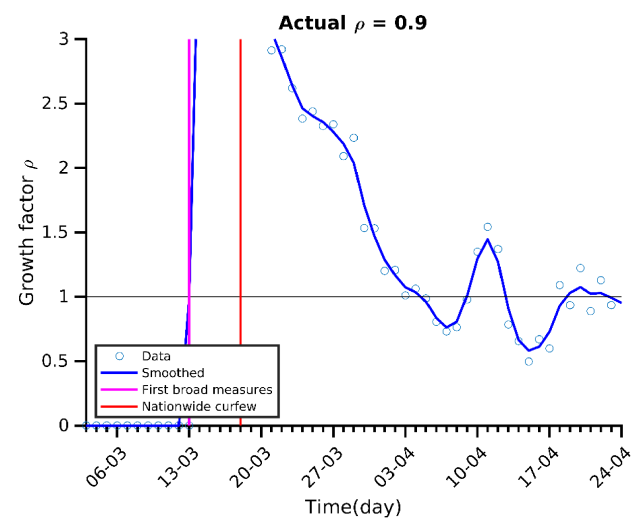
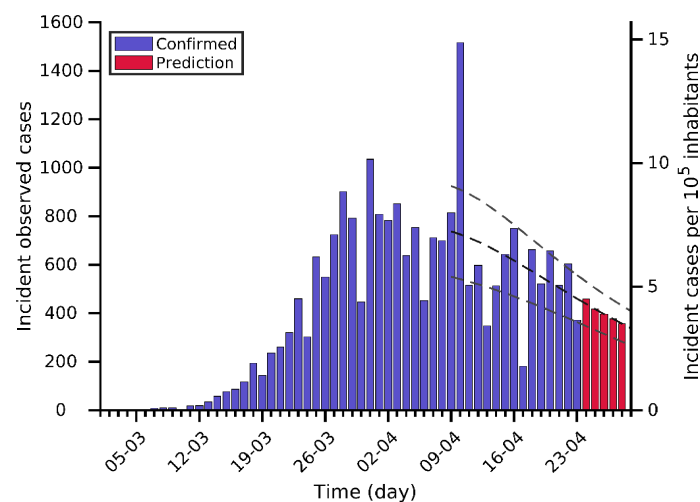
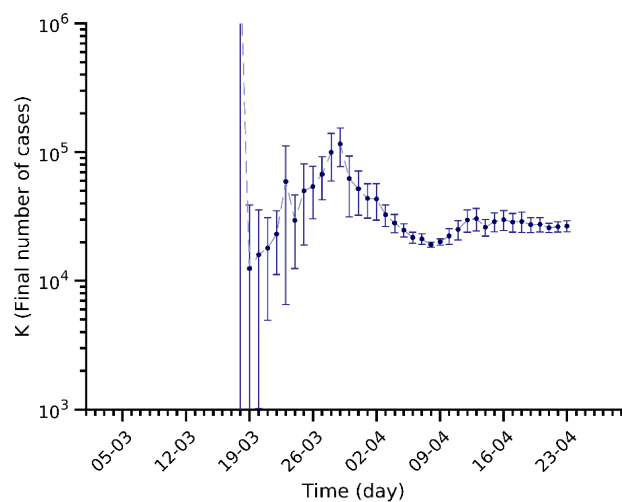
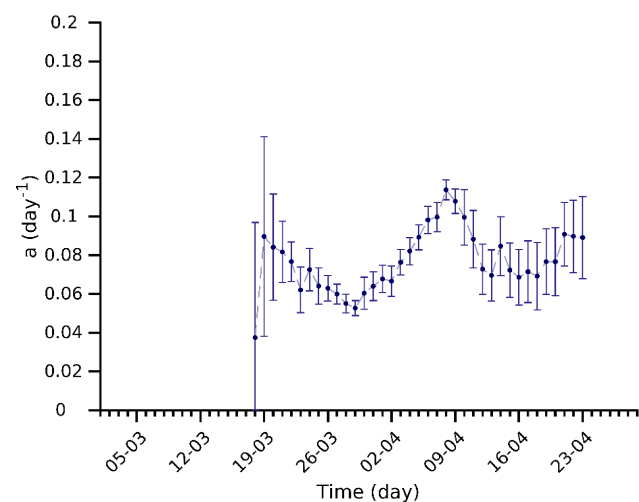
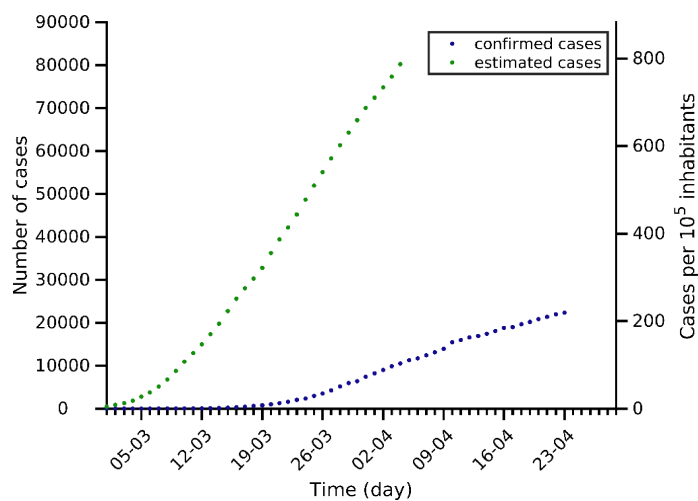
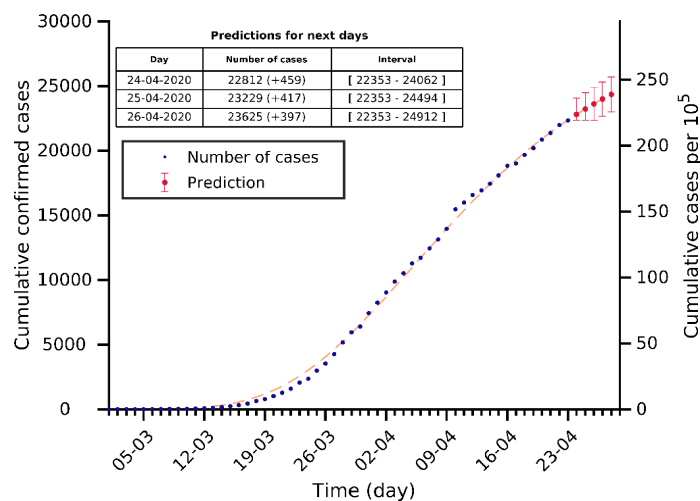
Netherlands 23-04-2020. Population: 17.1M. Current cumulated incidence: 209/10⁵



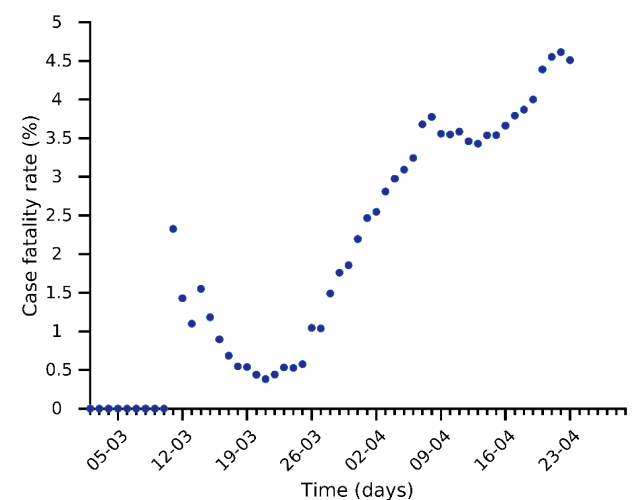
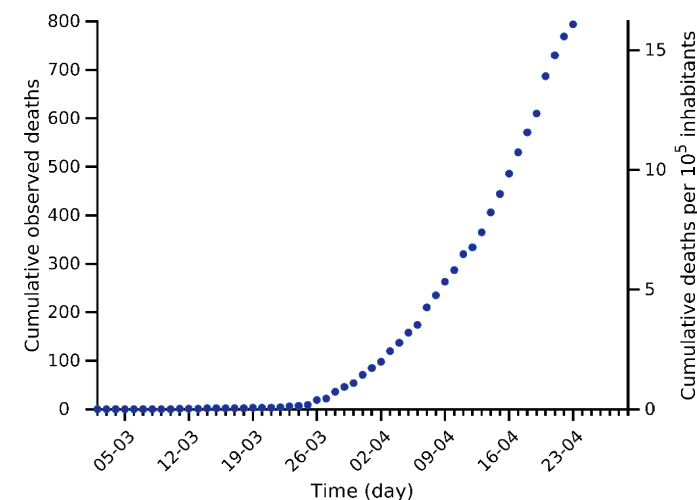
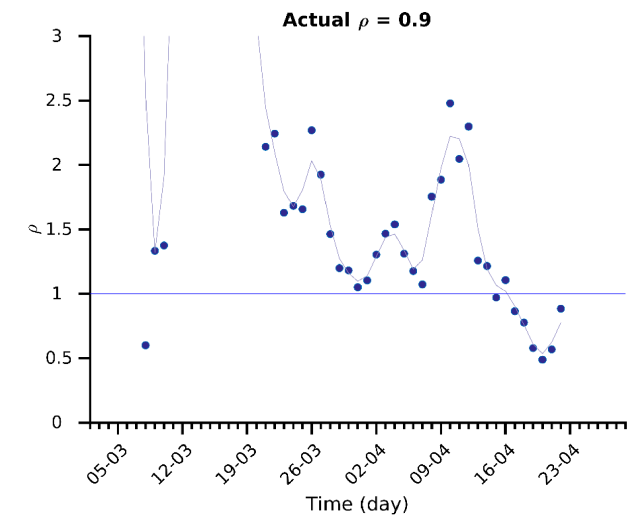
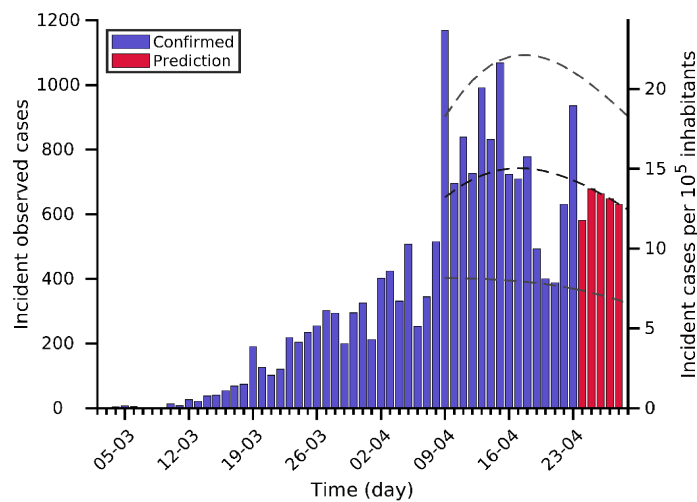
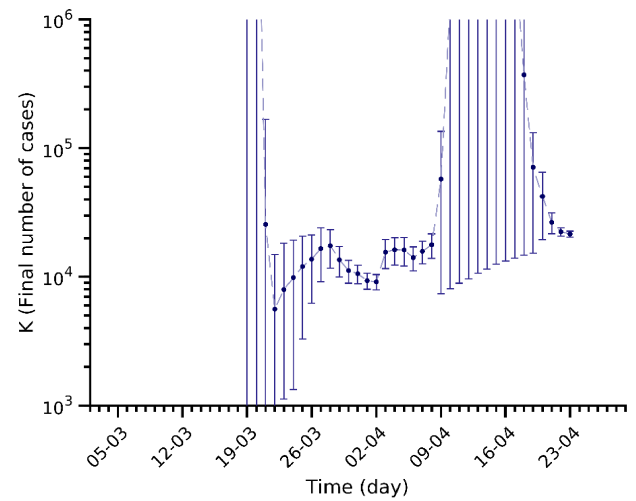
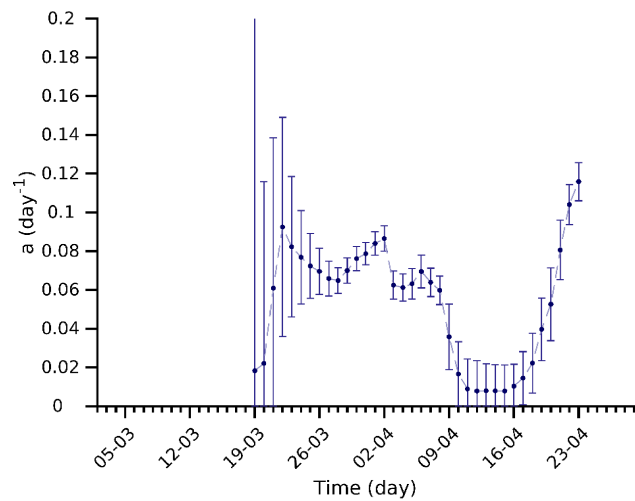
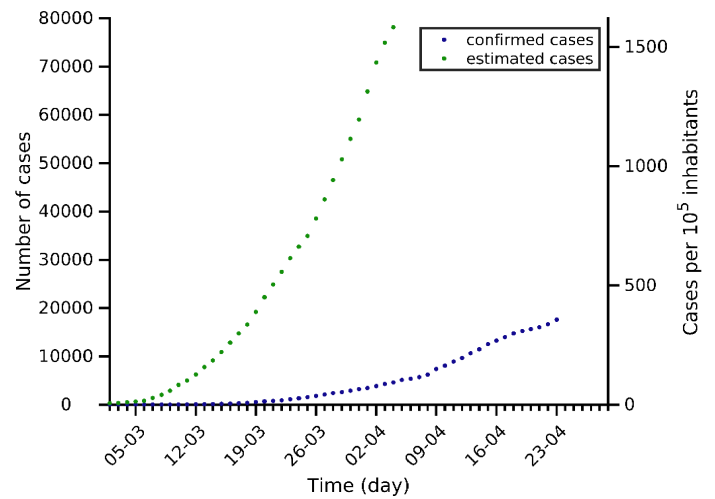
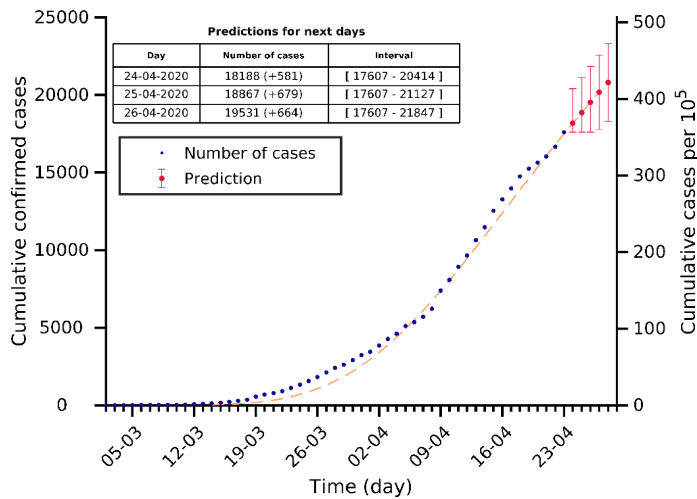
Switzerland 23-04-2020. Population: 8.7M. Current cumulated incidence: 328/10⁵



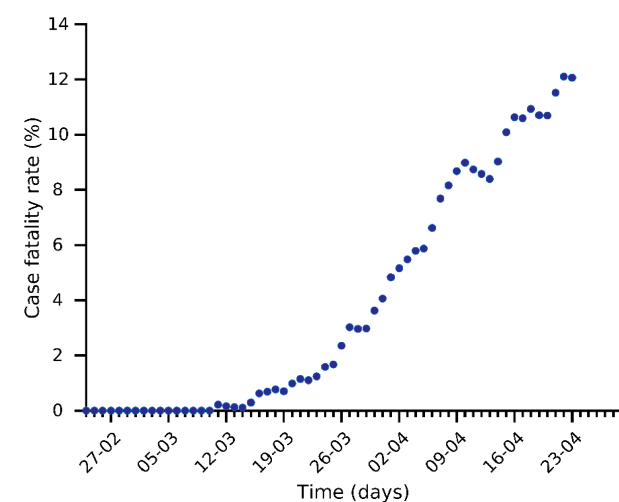
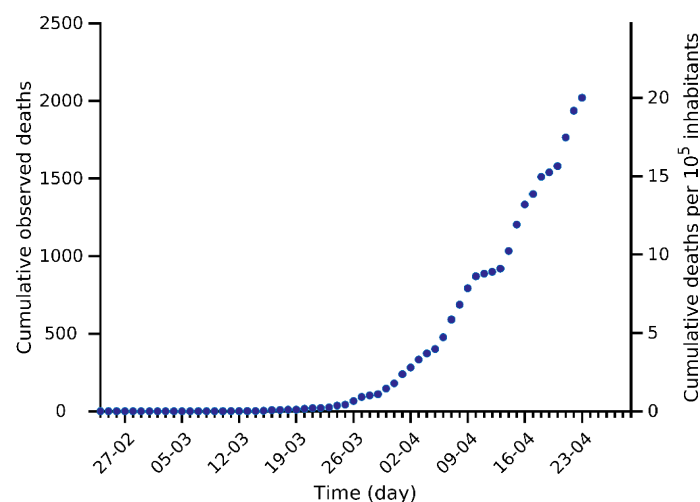
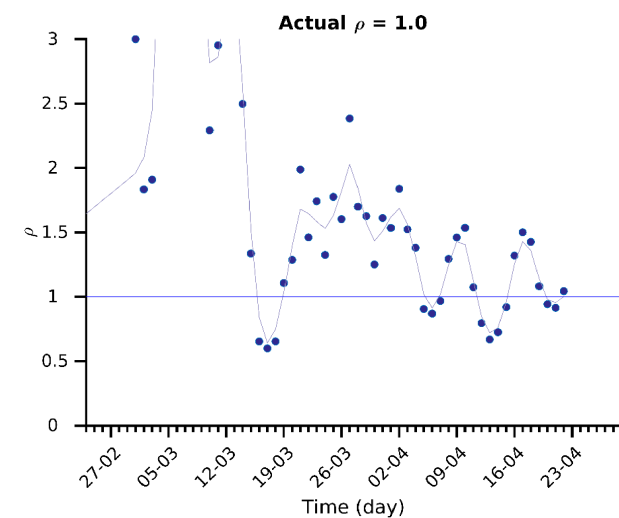
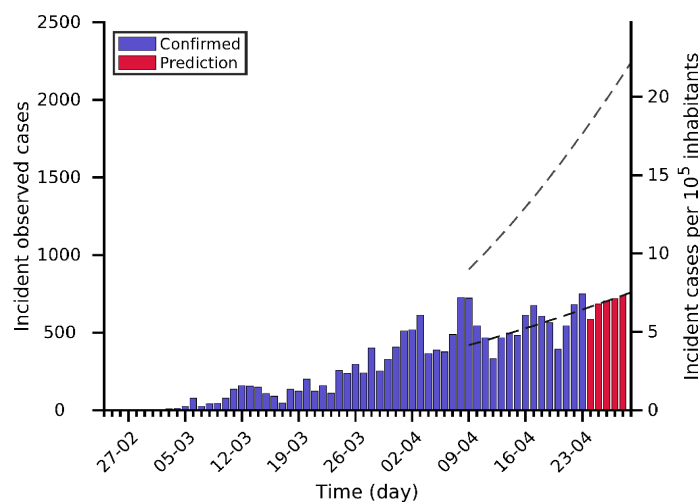
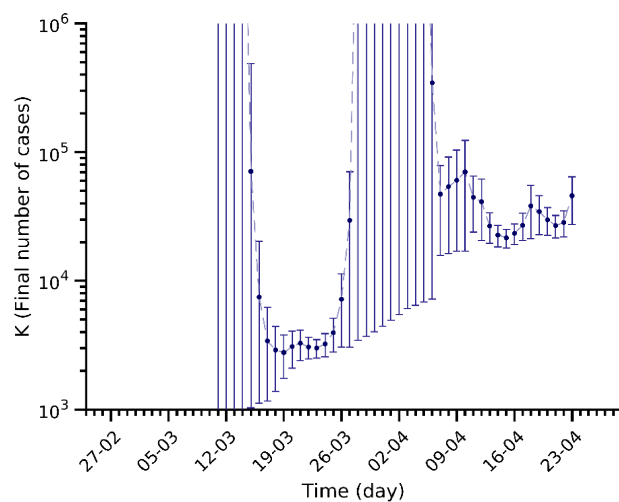
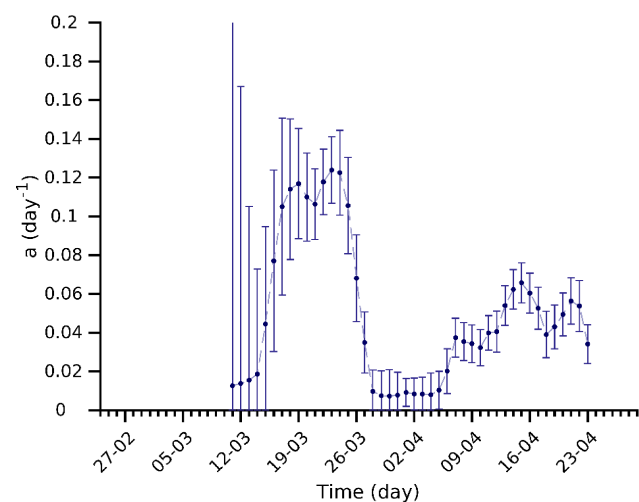
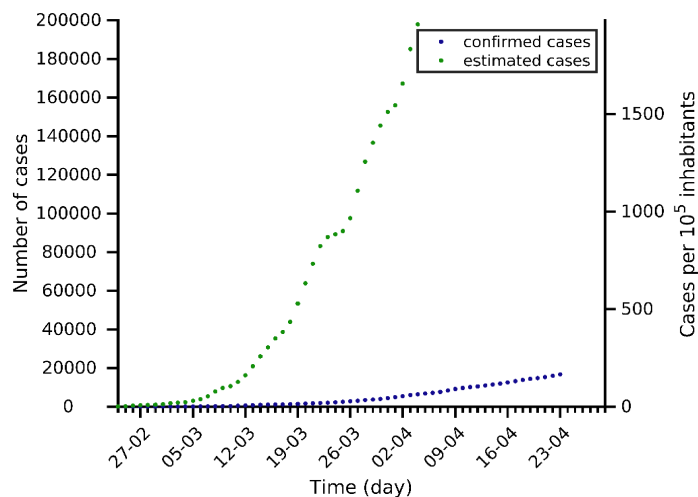
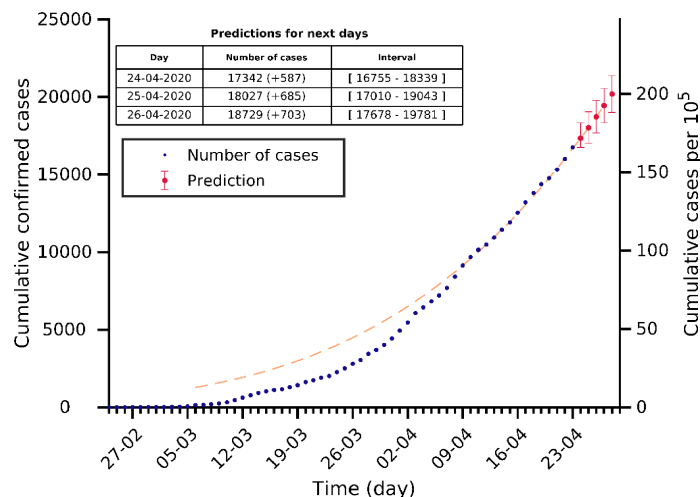
Portugal 23-04-2020. Population: 10.2M. Current cumulated incidence: 219/10⁵



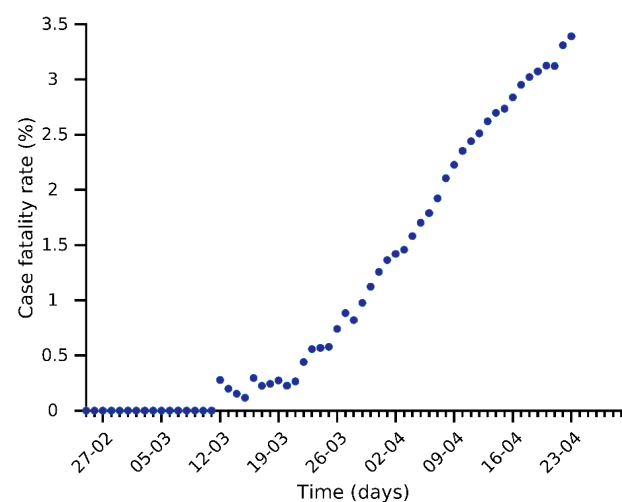
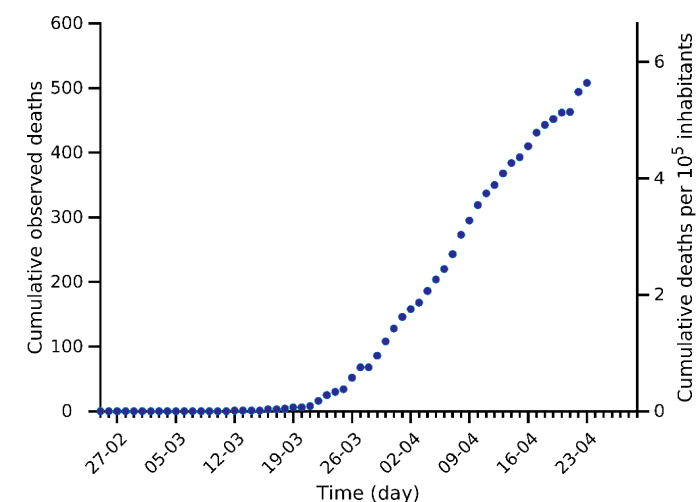
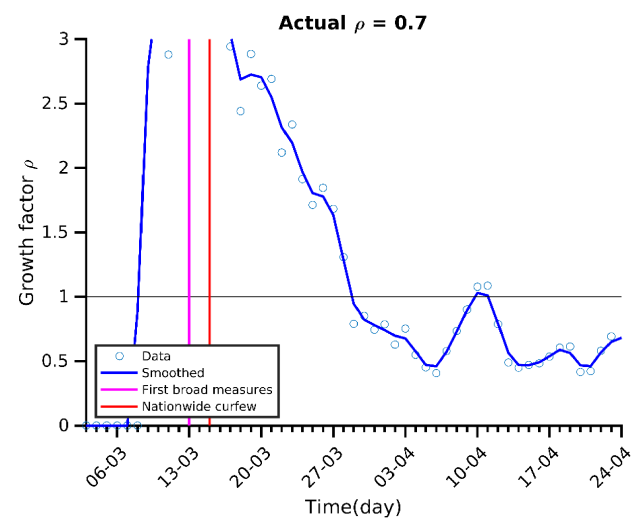
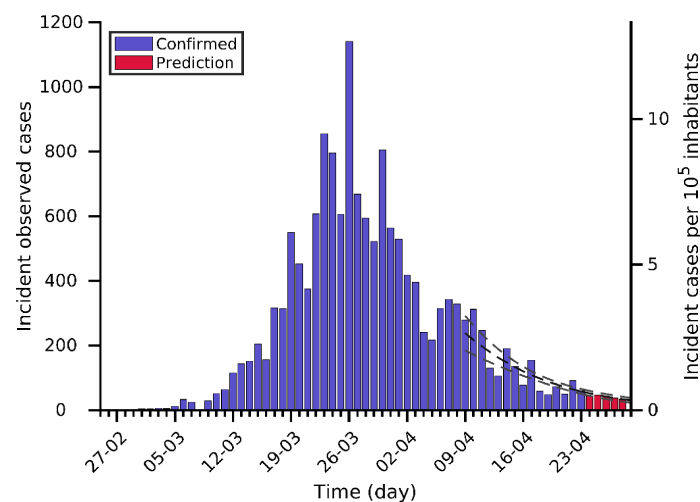
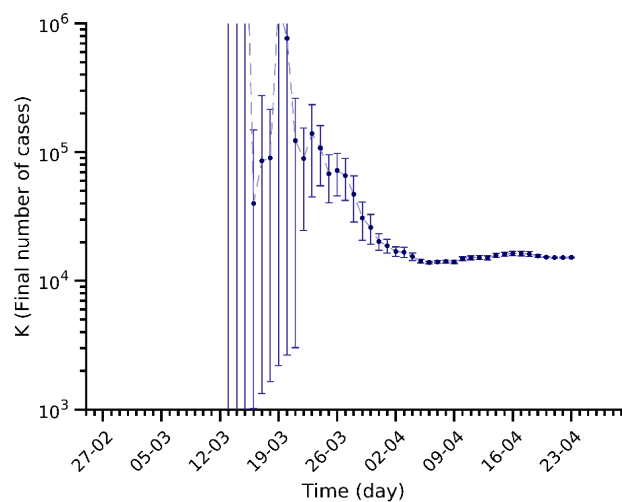
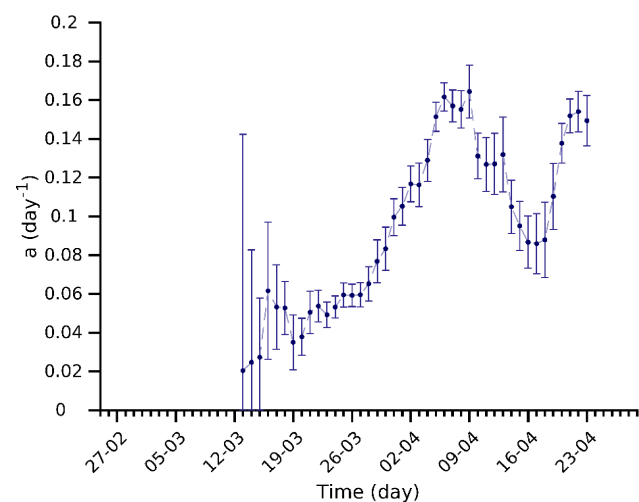
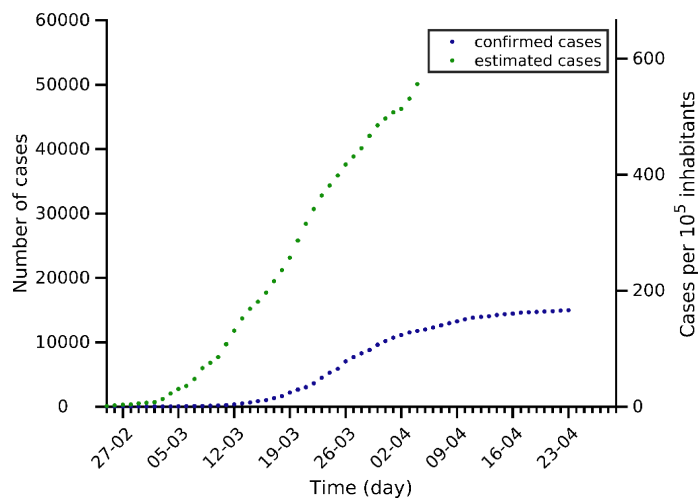
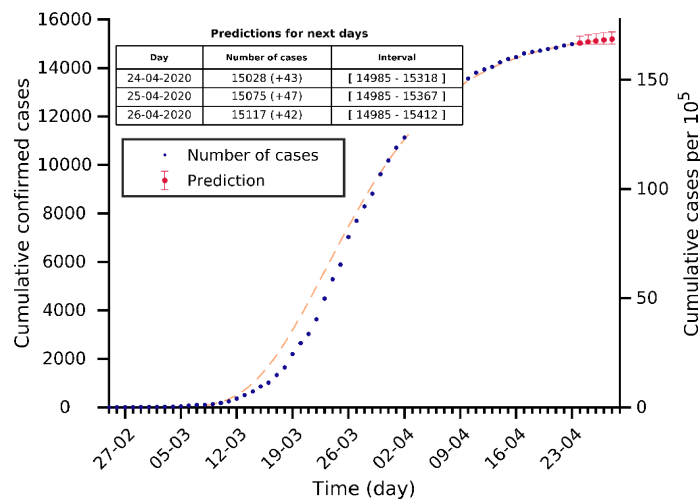
Ireland 23-04-2020. Population: 4.9M. Current cumulated incidence: 357/10⁵



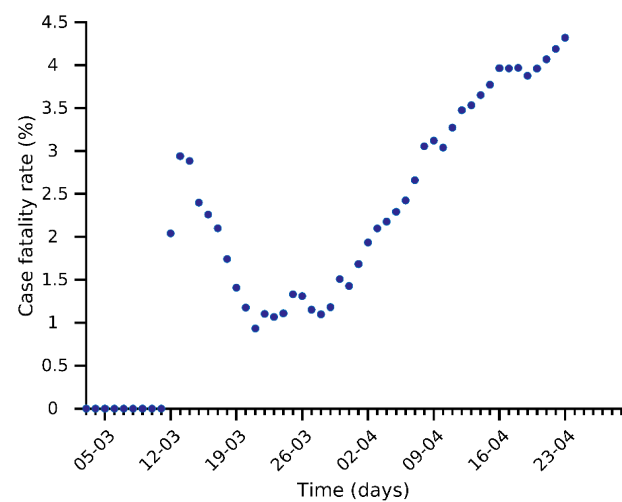
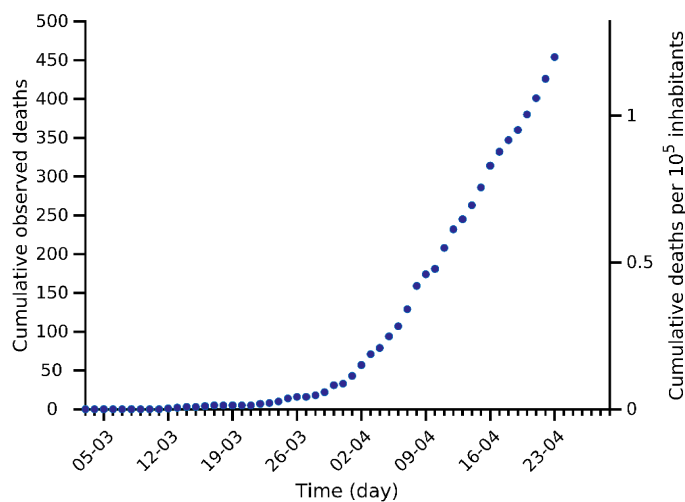
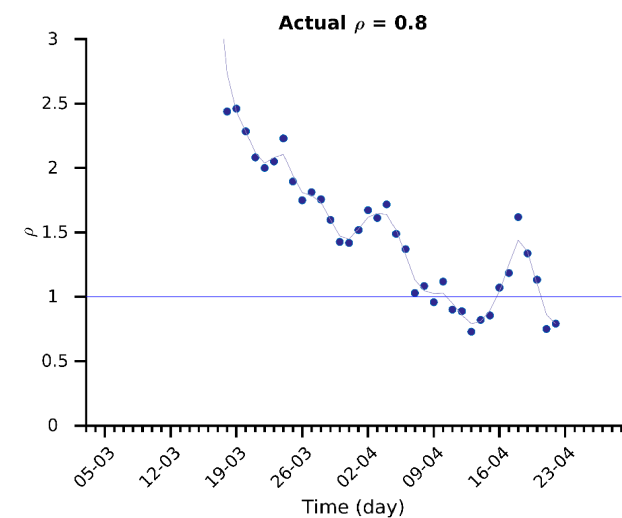
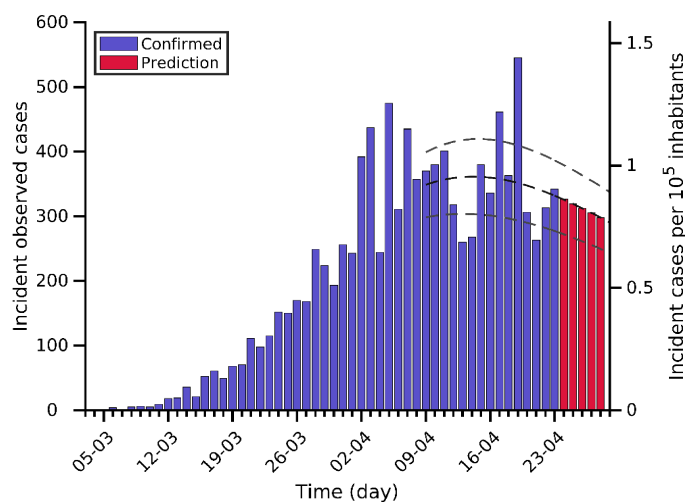
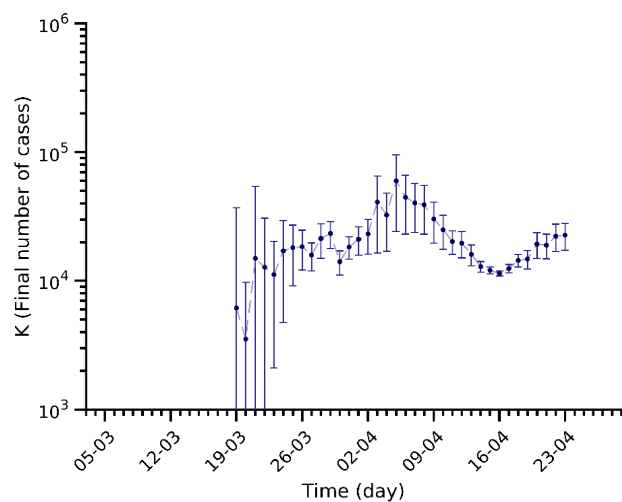
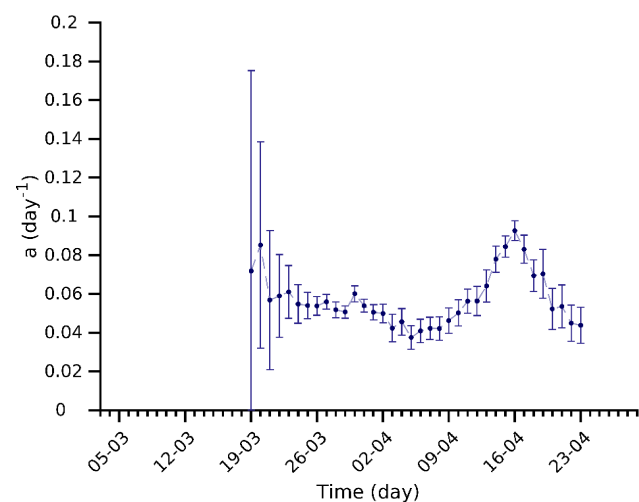
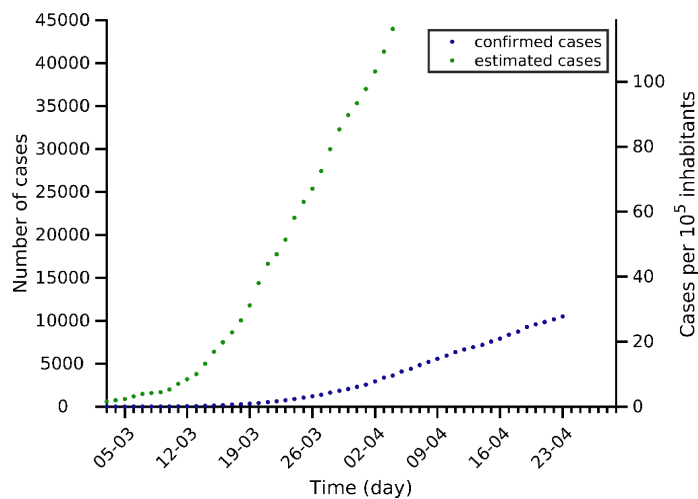
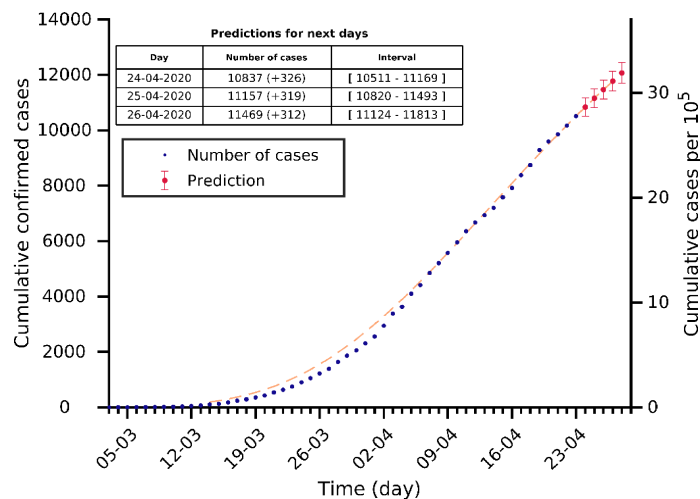
Sweden 23-04-2020. Population: 10.1M. Current cumulated incidence: 166/10⁵



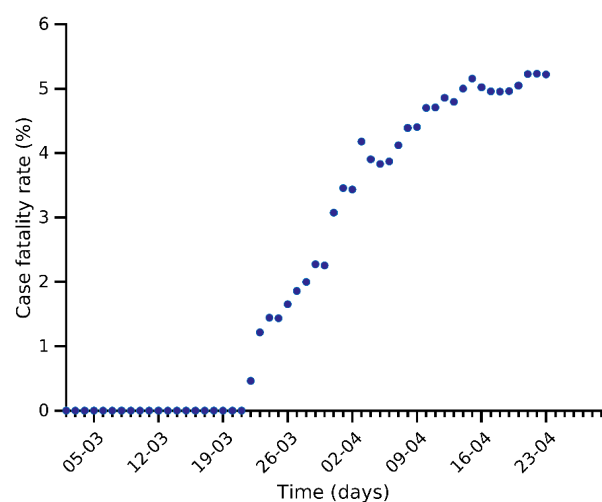
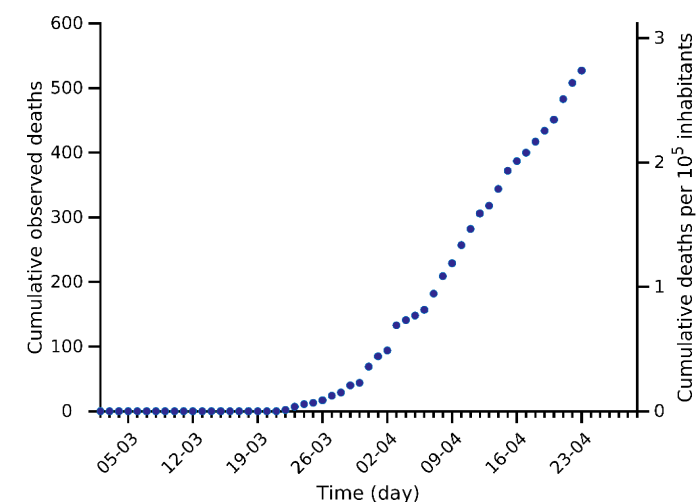
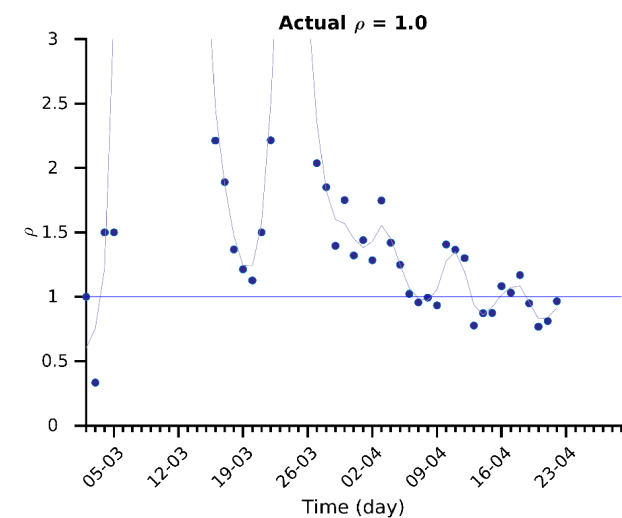
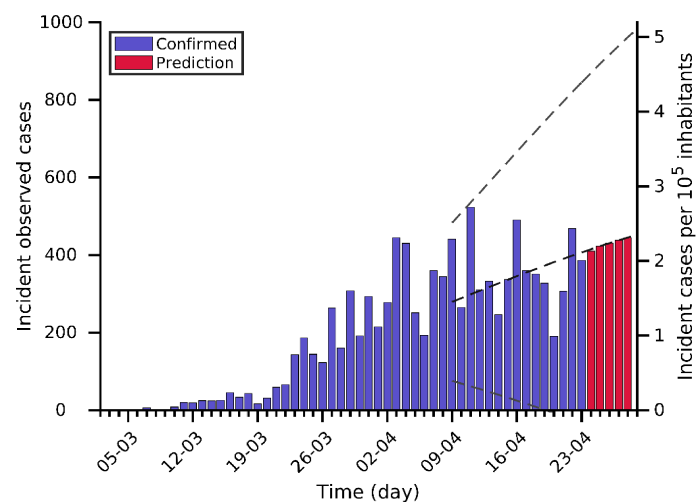
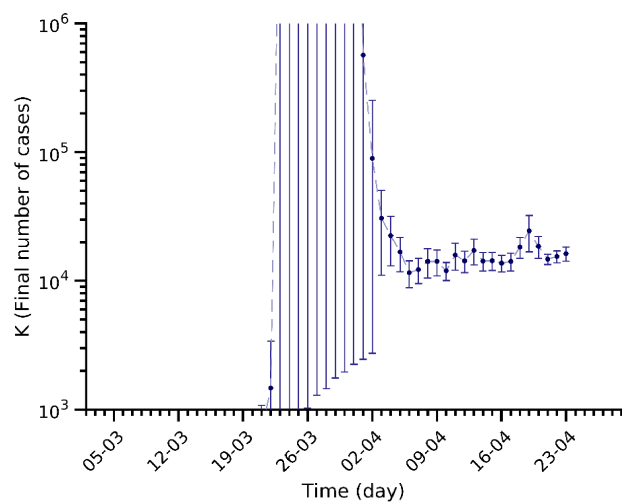
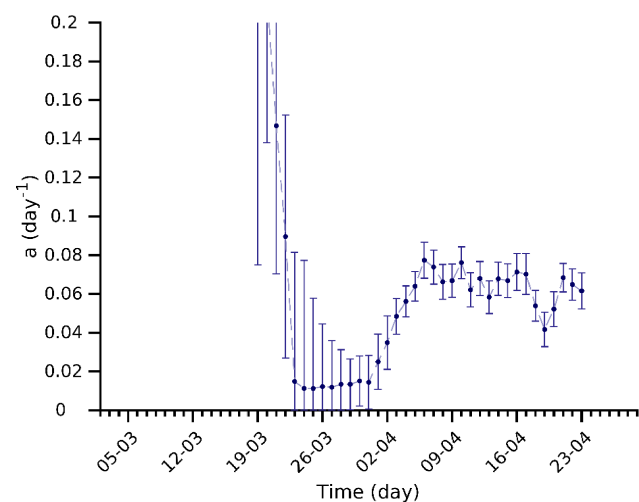
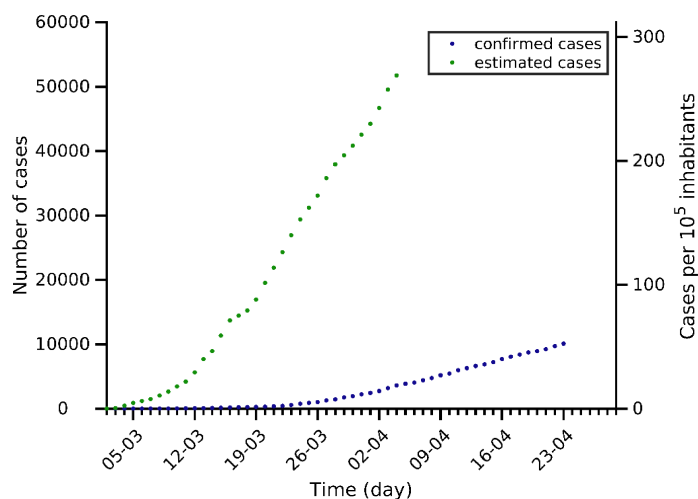
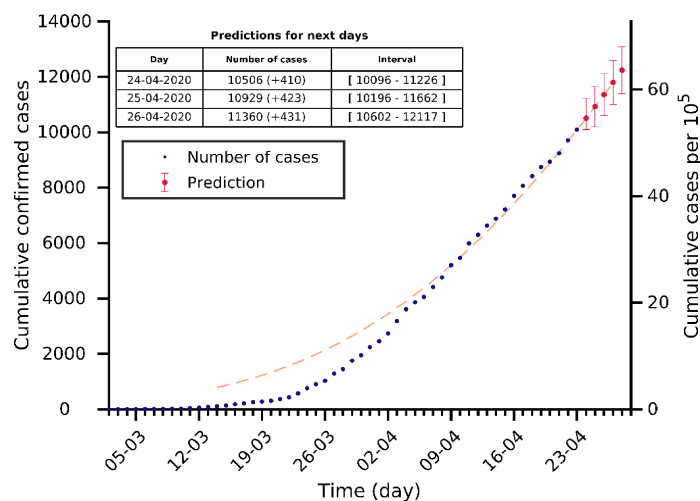
Austria 23-04-2020. Population: 9.0M. Current cumulated incidence: 166/10⁵



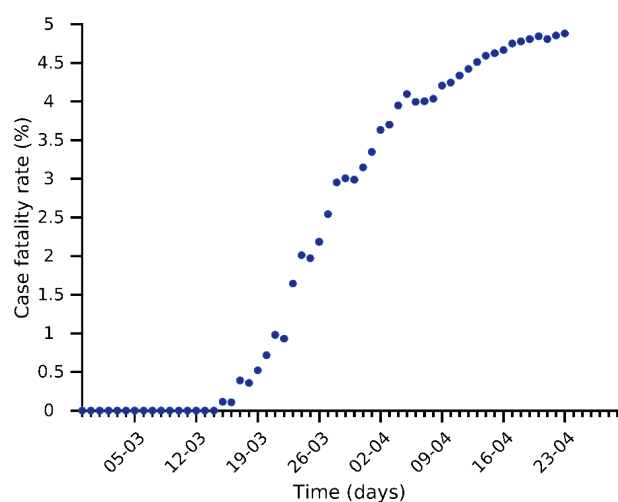
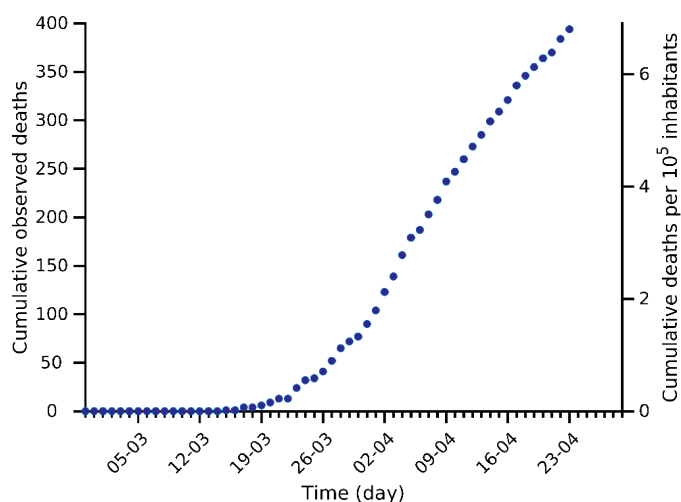
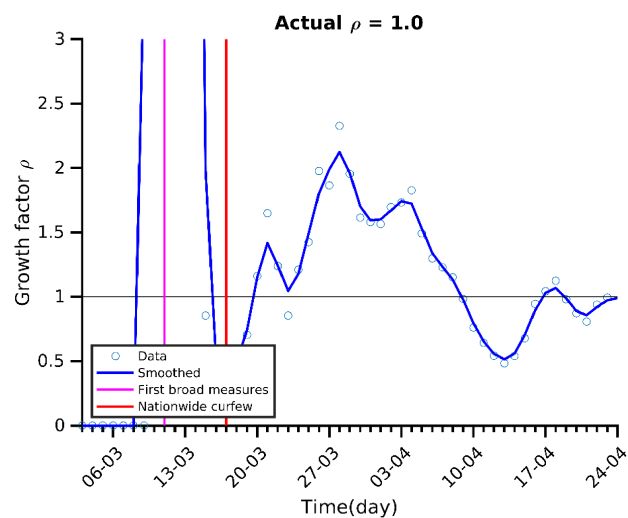
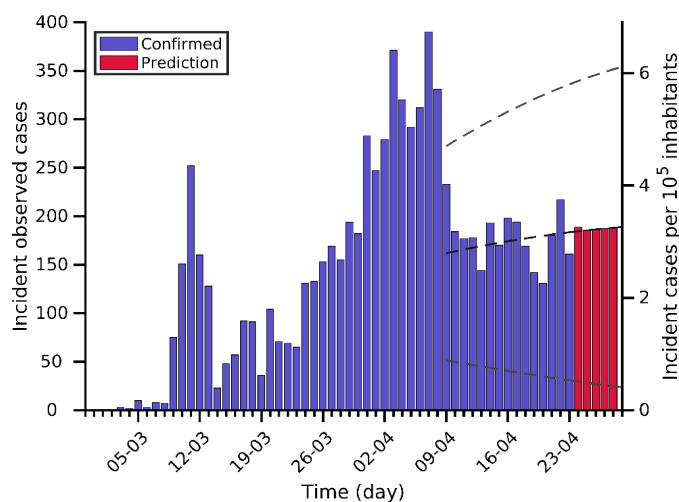
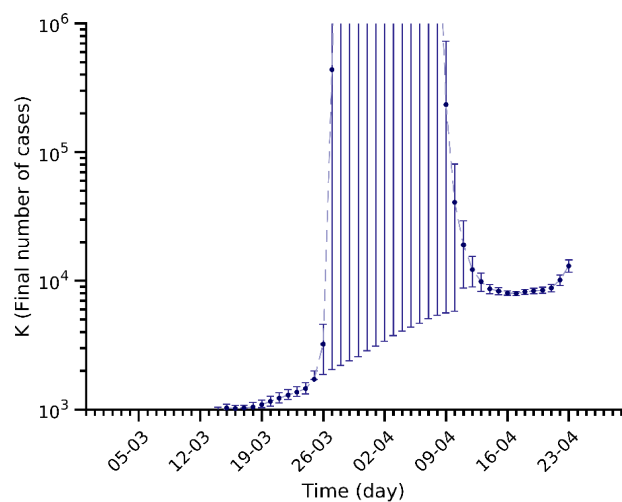
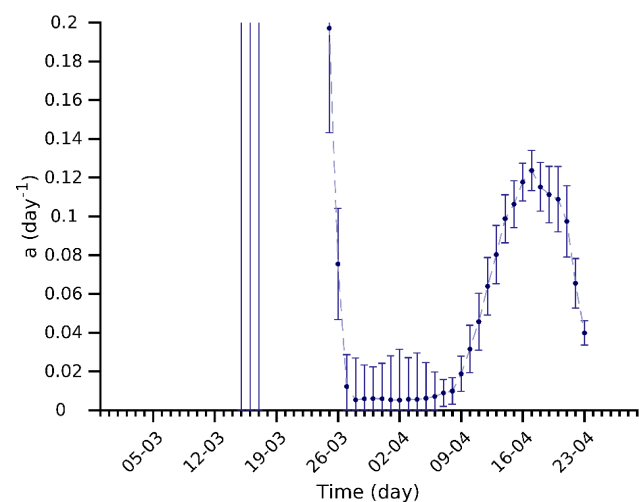
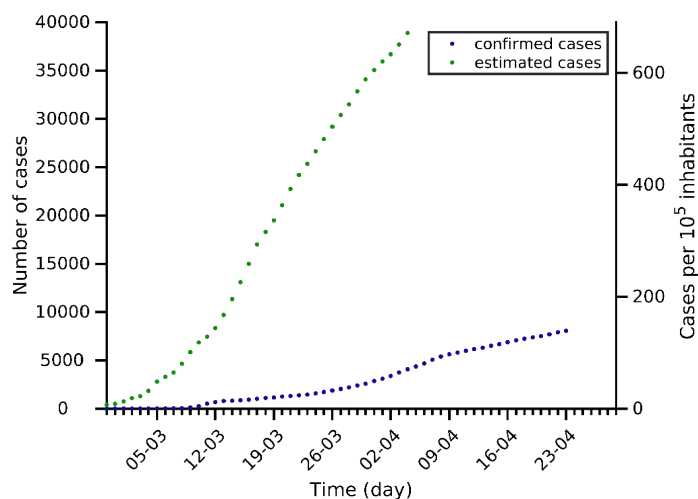
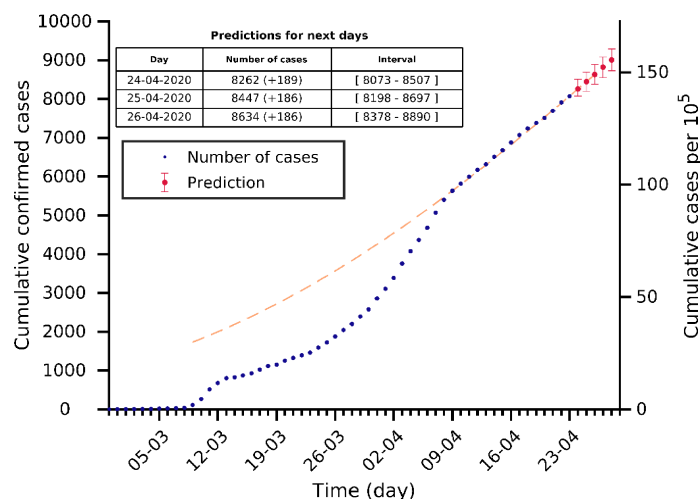
Poland 23-04-2020. Population: 37.8M. Current cumulated incidence: 28/10⁵



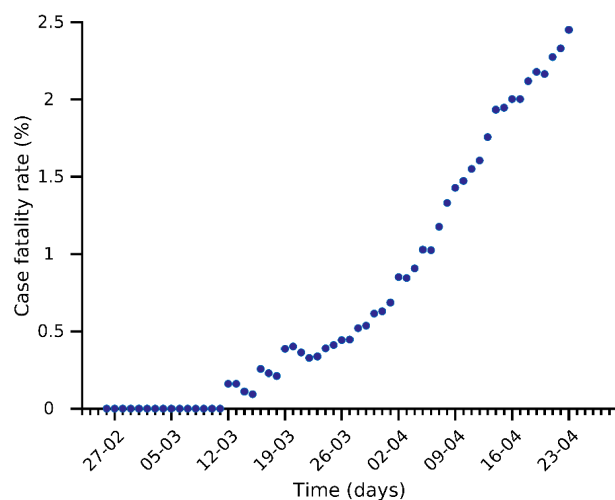
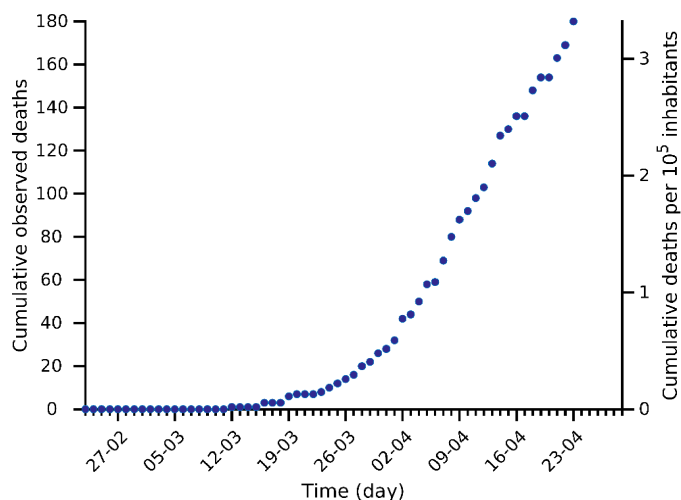
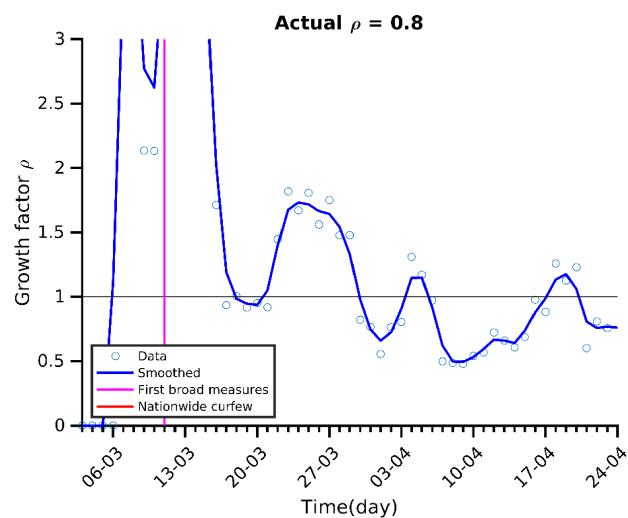
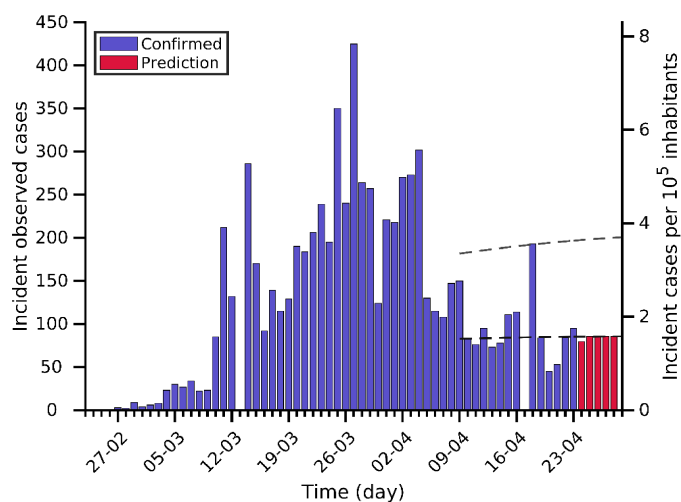
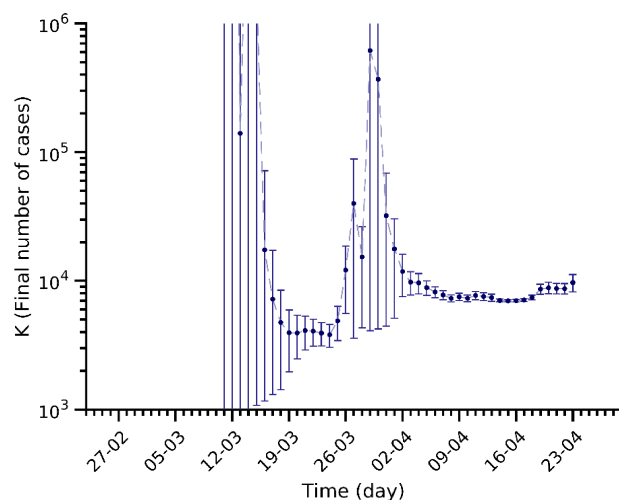
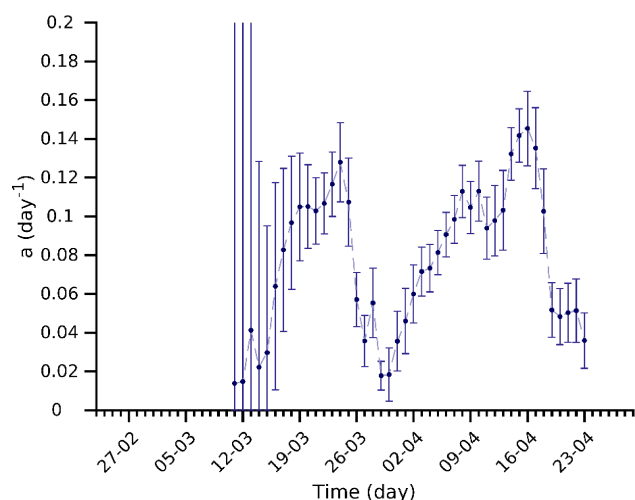
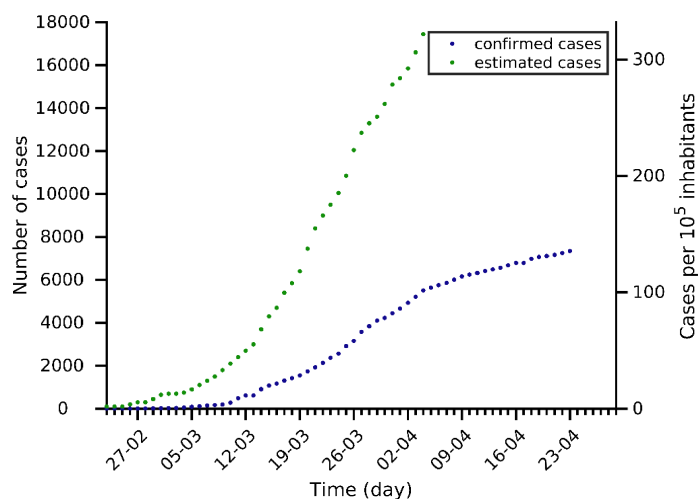
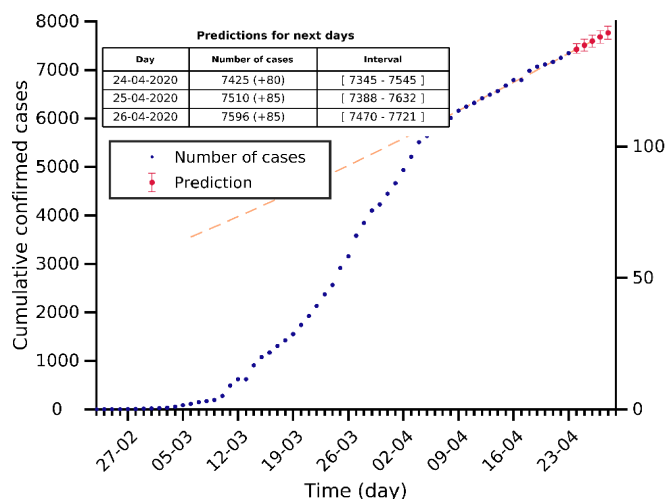
Romania 23-04-2020. Population: 19.2M. Current cumulated incidence: 52/10⁵



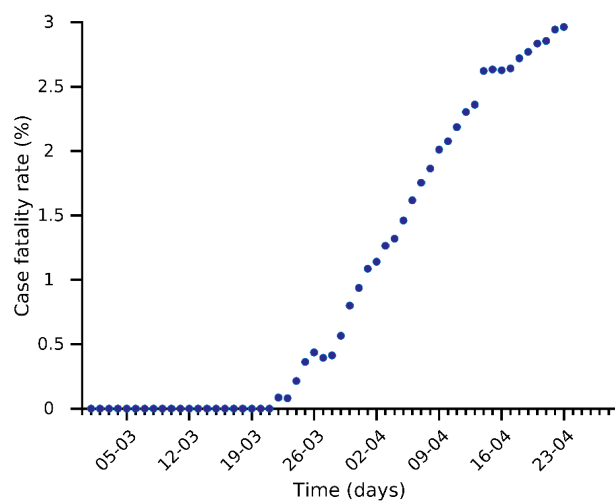
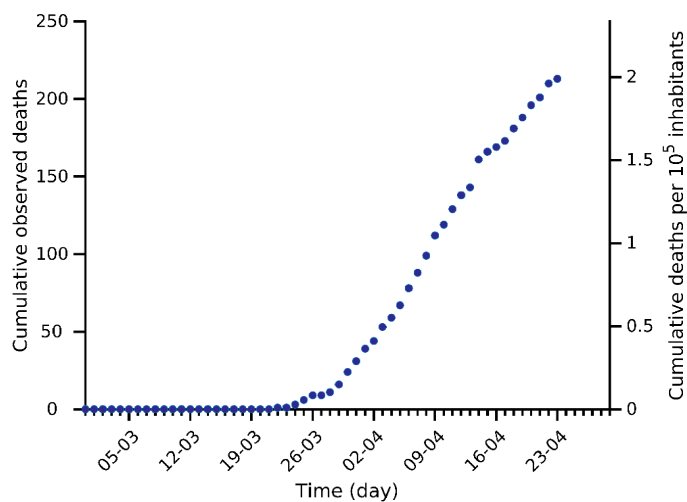
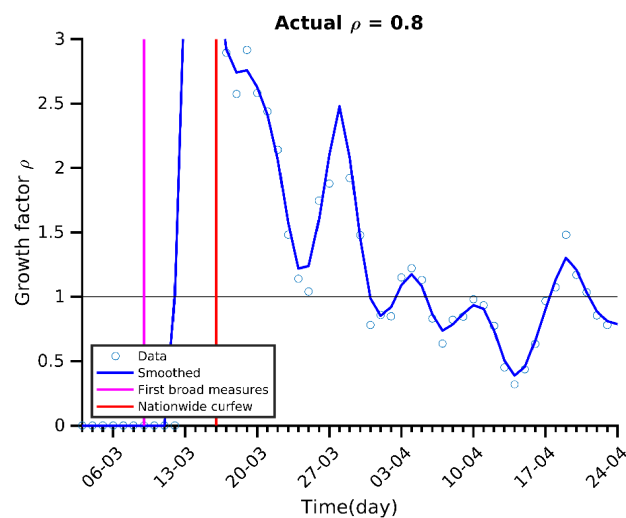
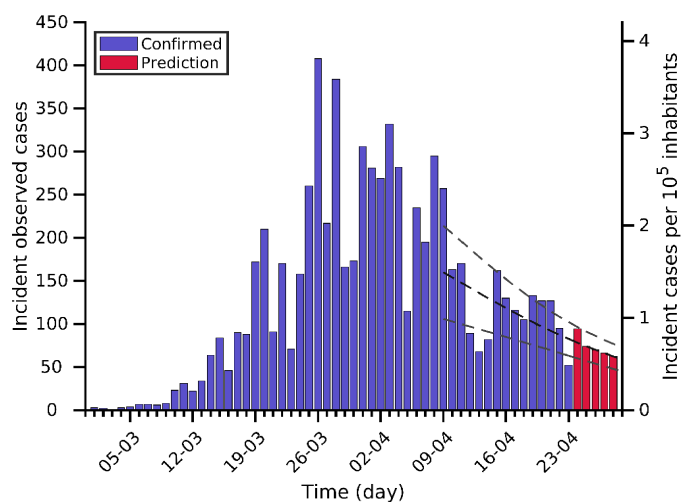
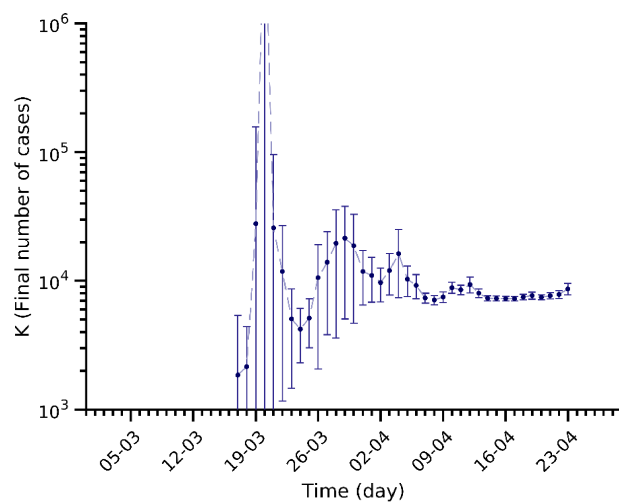
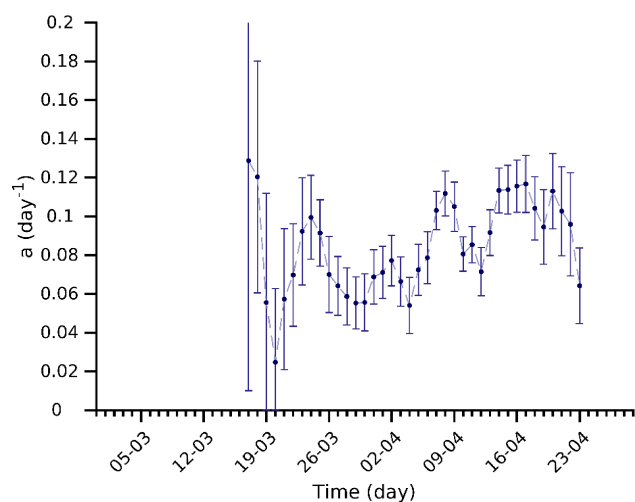
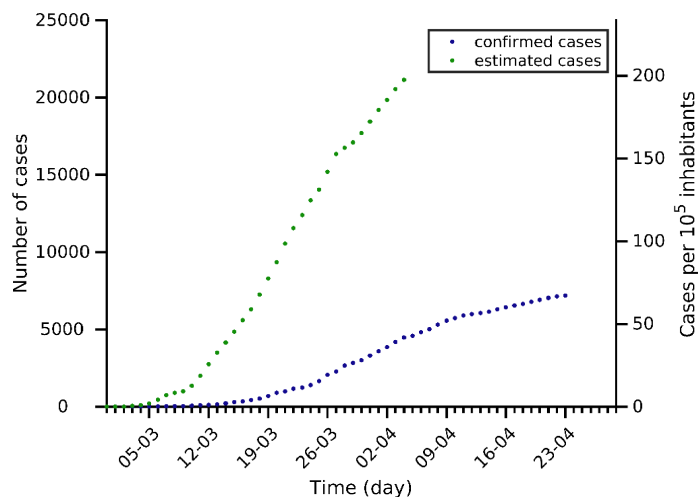
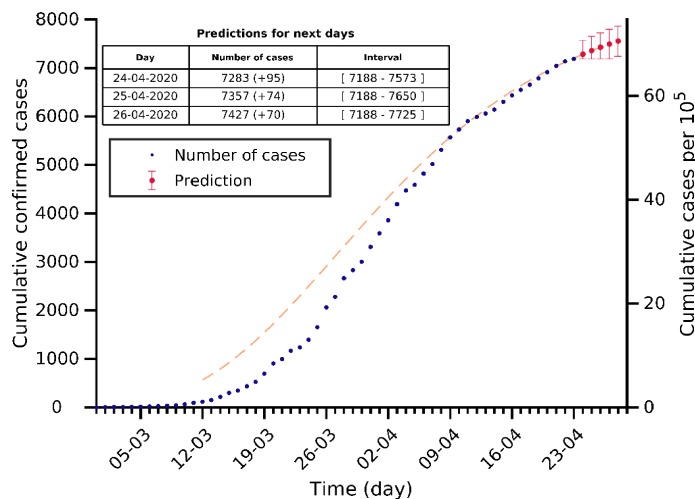
Denmark 23-04-2020. Population: 5.8M. Current cumulated incidence: 139/10⁵



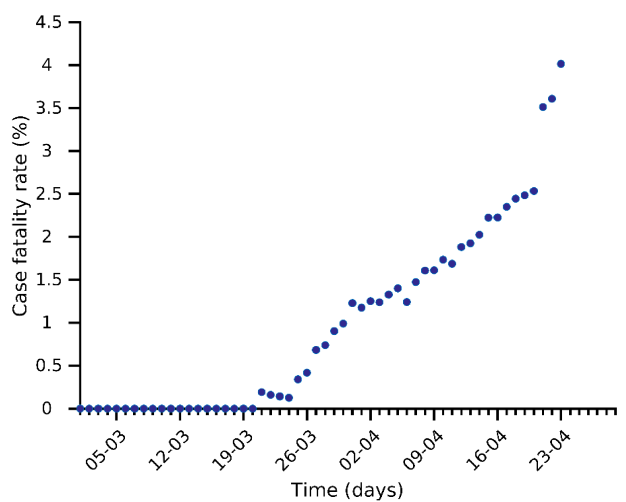
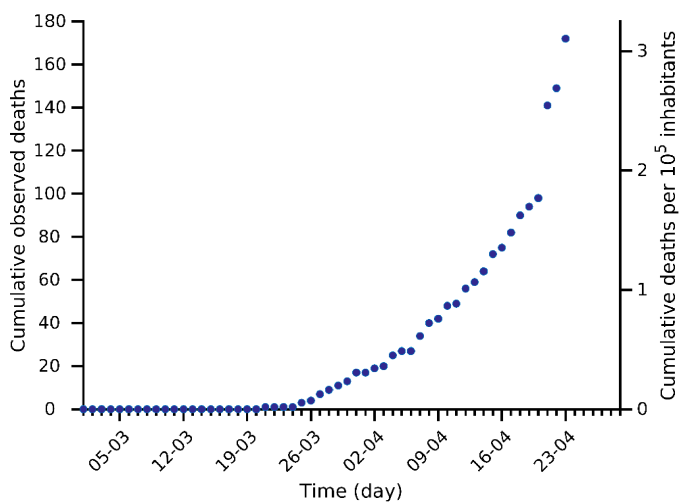
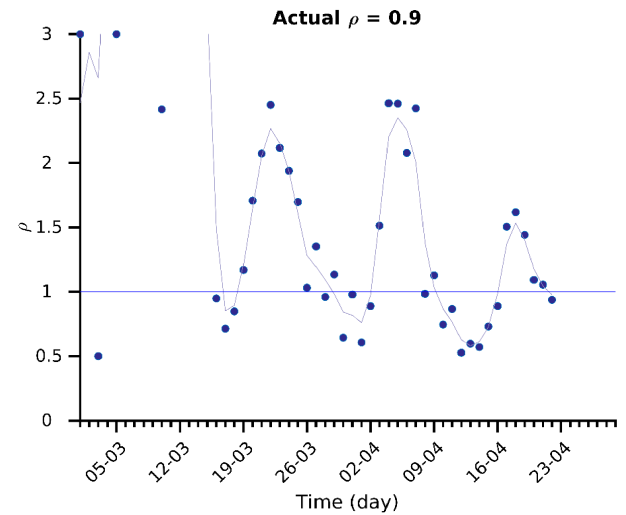
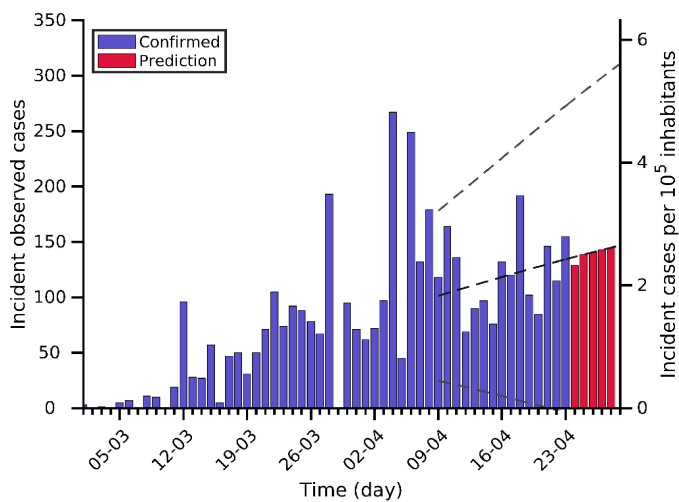
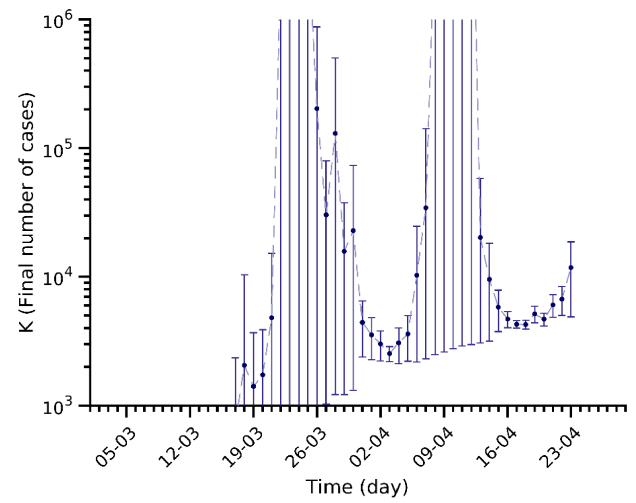
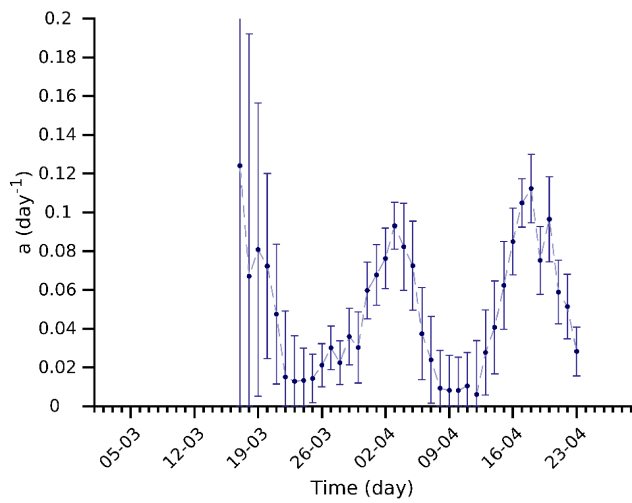
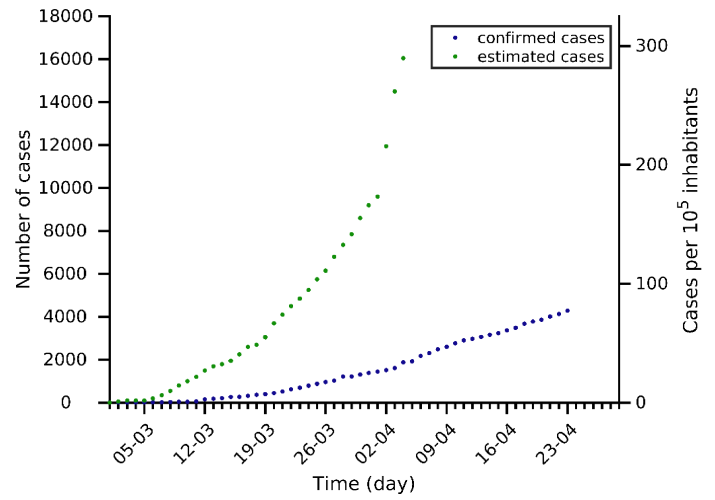
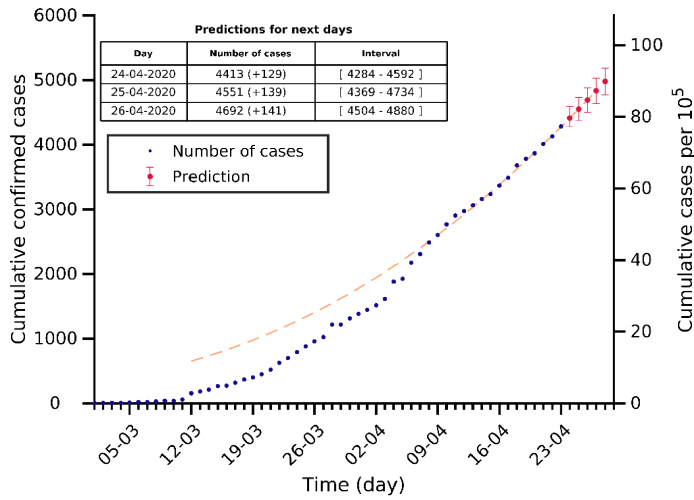
Norway 23-04-2020. Population: 5.4M. Current cumulated incidence: 135/10⁵



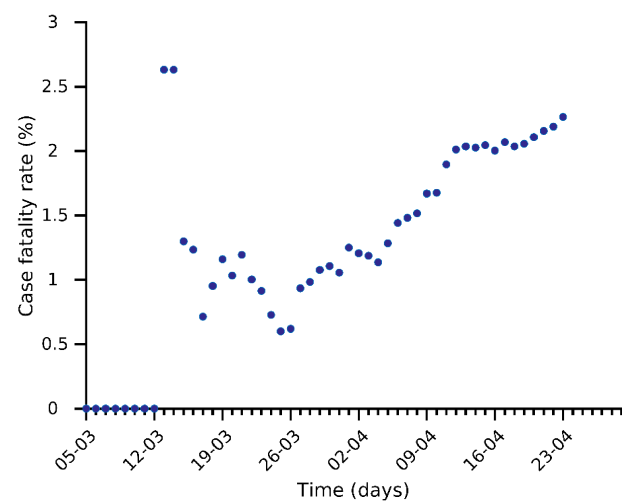
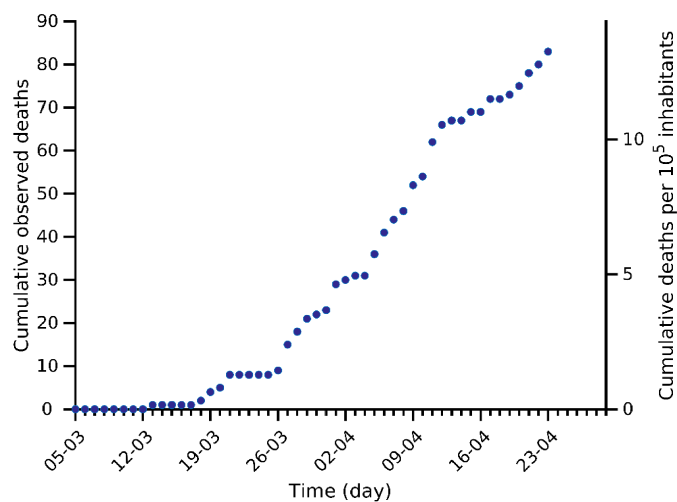
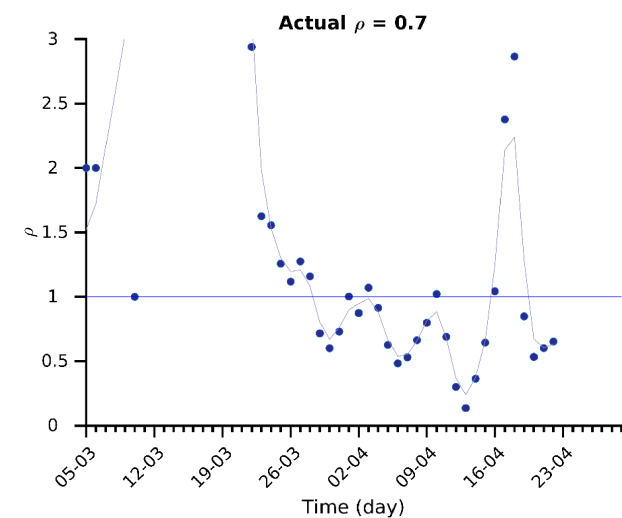
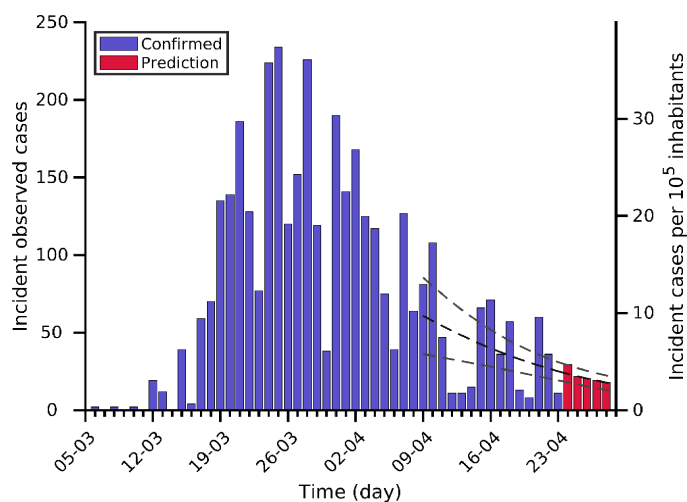
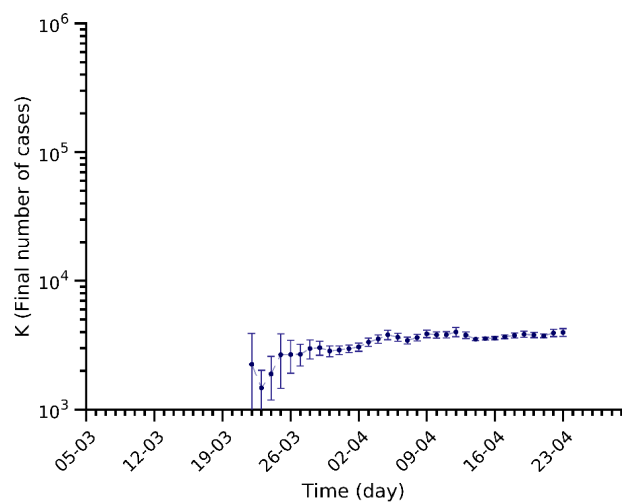
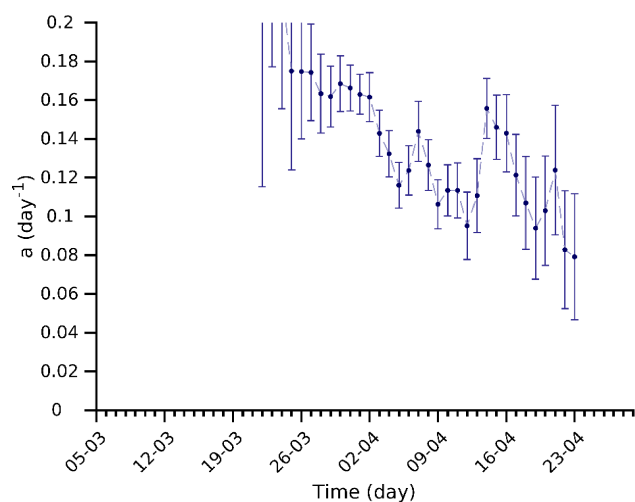
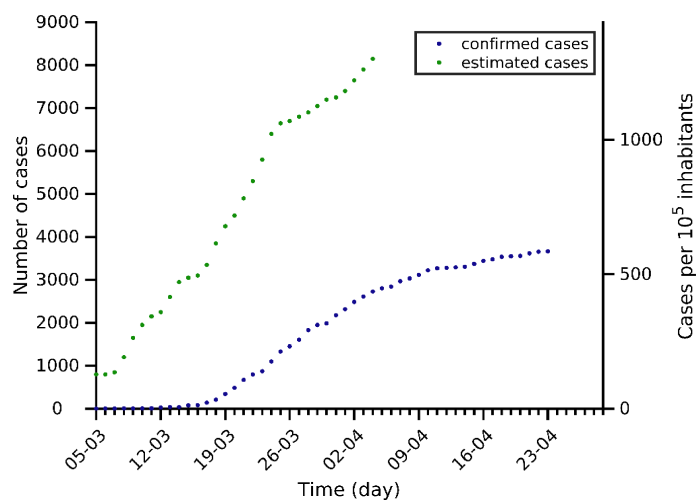
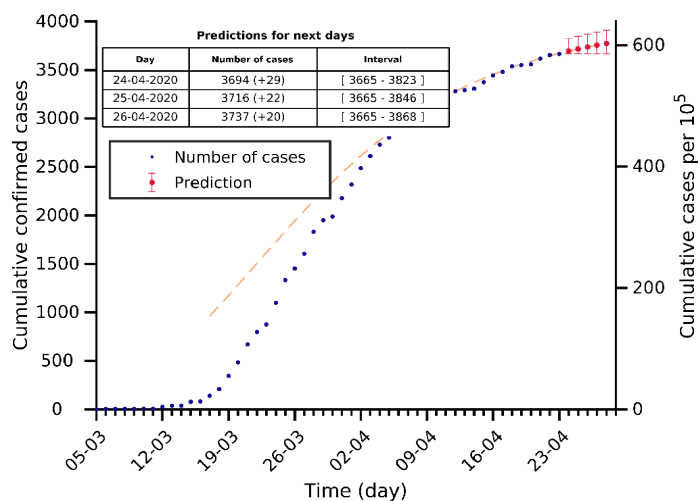
Czech Rep 23-04-2020. Population: 10.7M. Current cumulated incidence: 67/10⁵



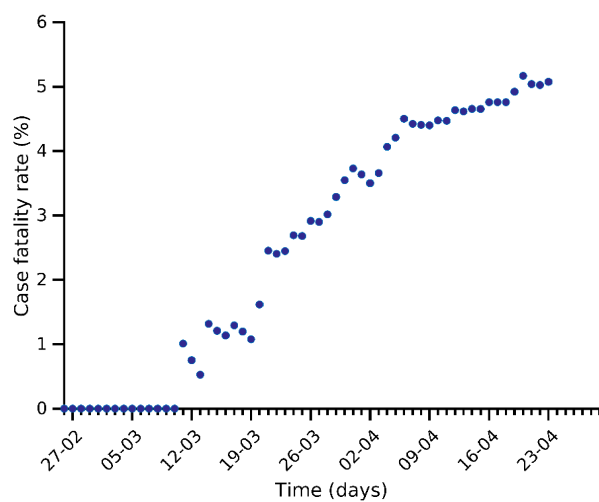
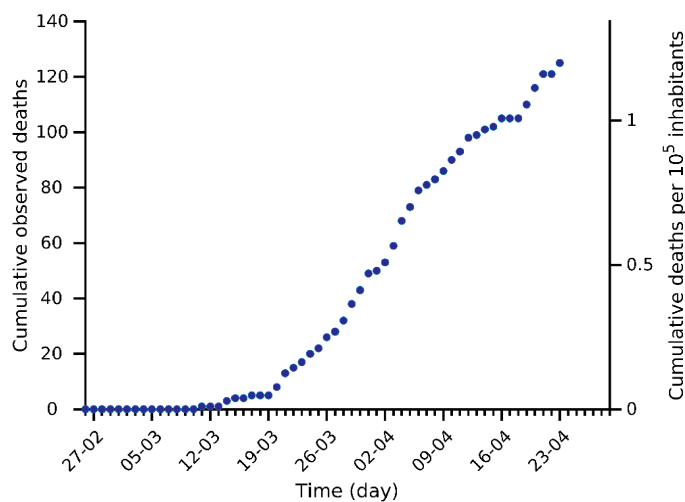
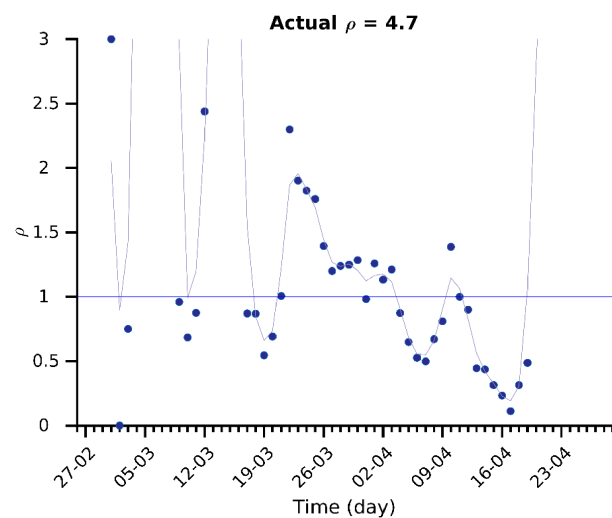
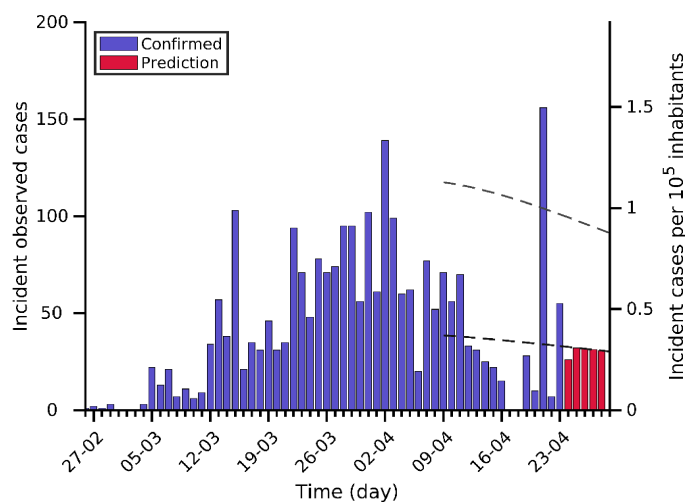
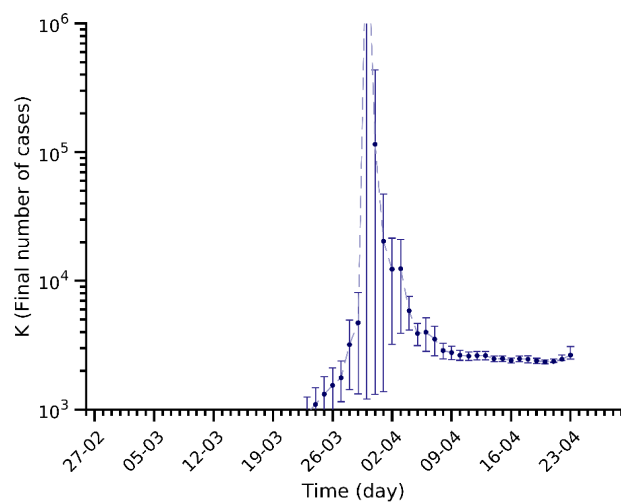
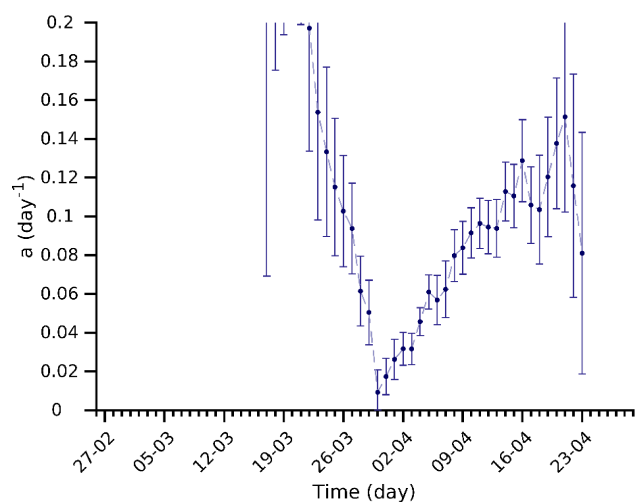
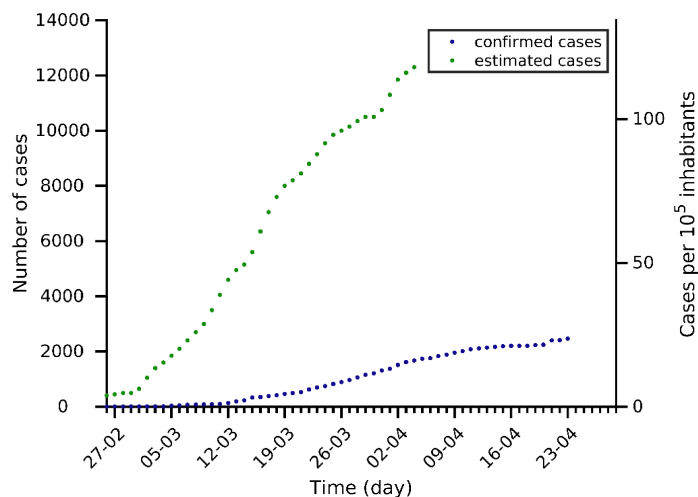
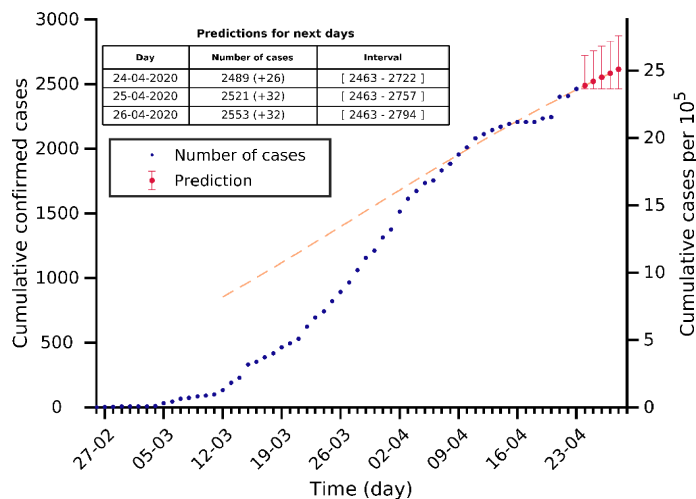
Finland 23-04-2020. Population: 5.5M. Current cumulated incidence: 77/10⁵



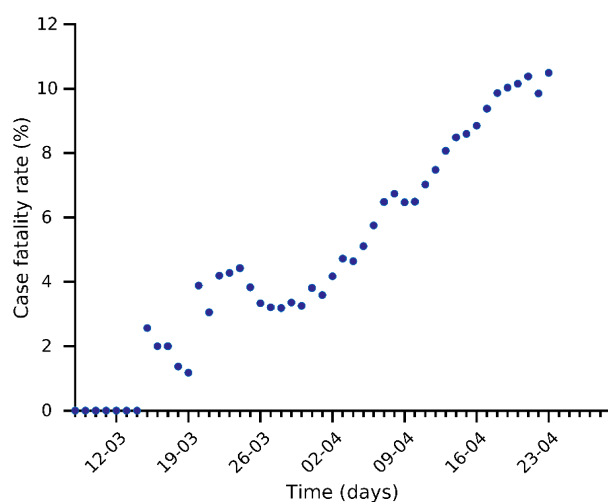
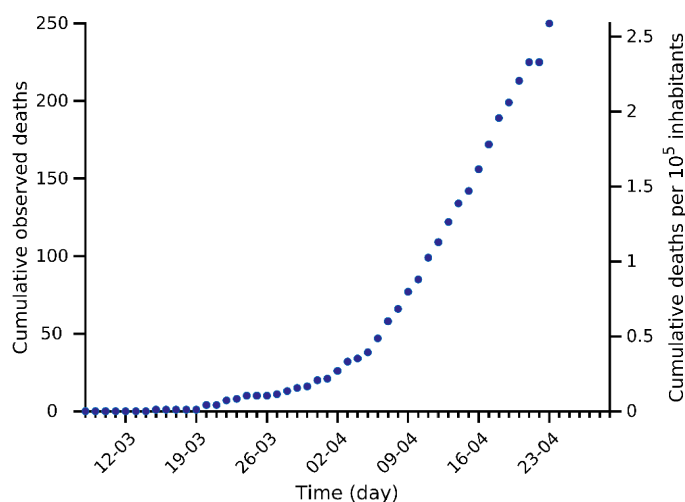
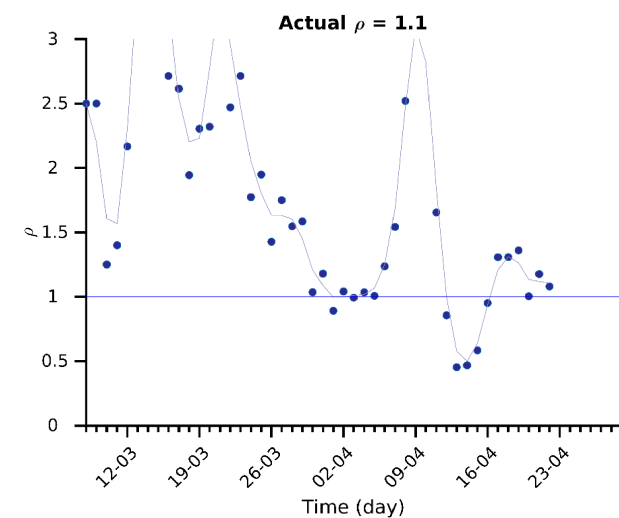
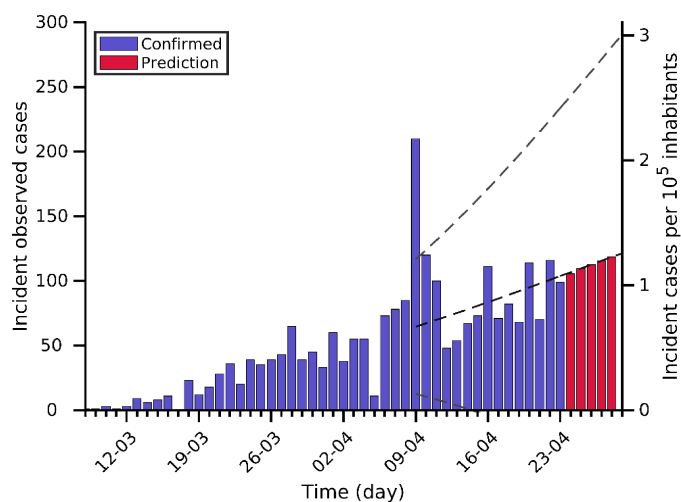
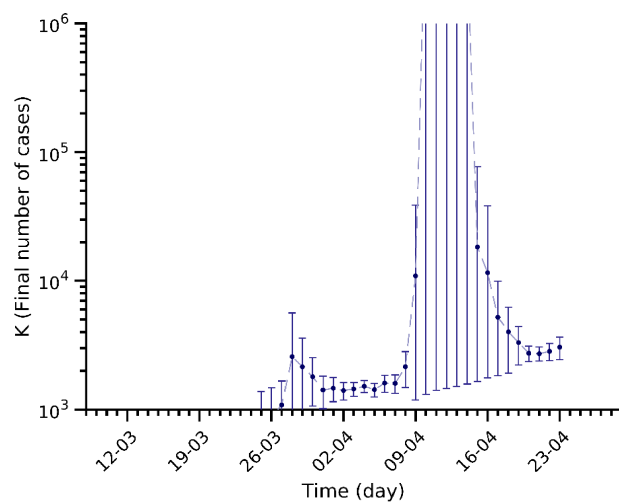
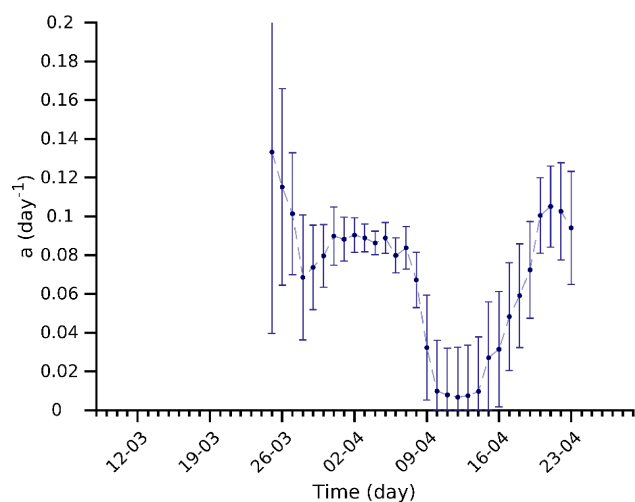
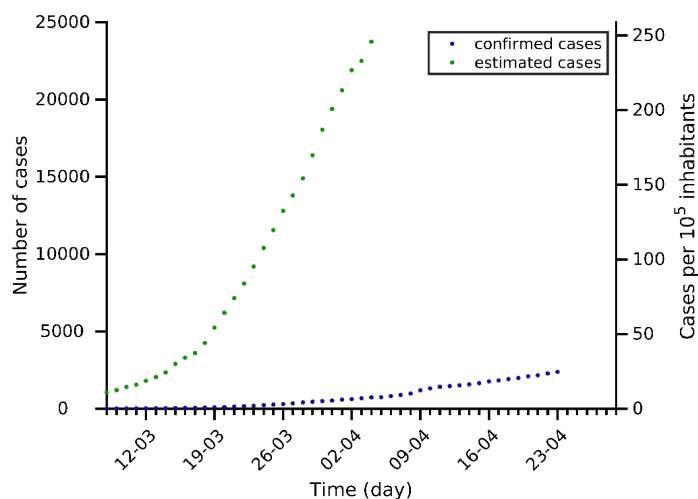
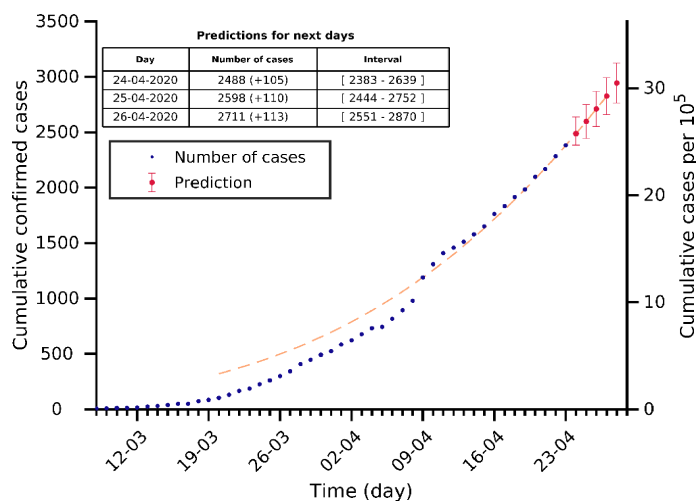
Luxembourg 23-04-2020. Population: 0.6M. Current cumulated incidence: 585/10⁵



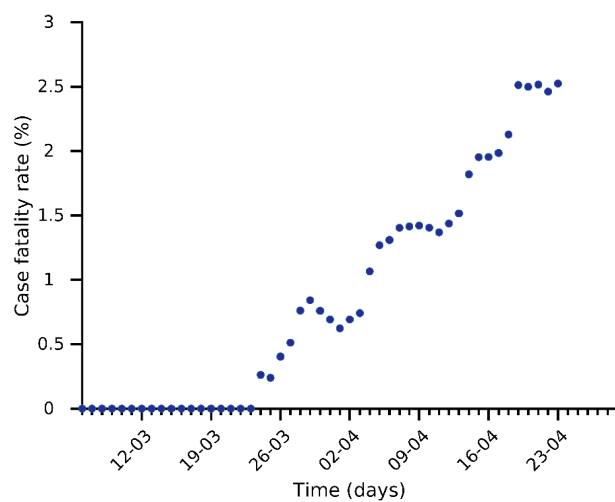
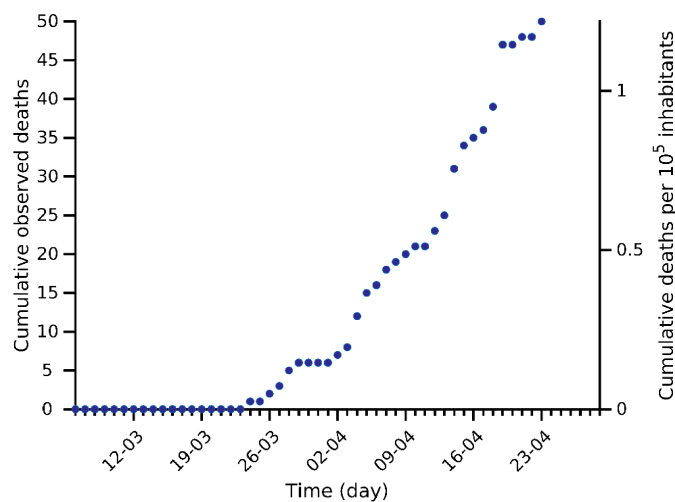
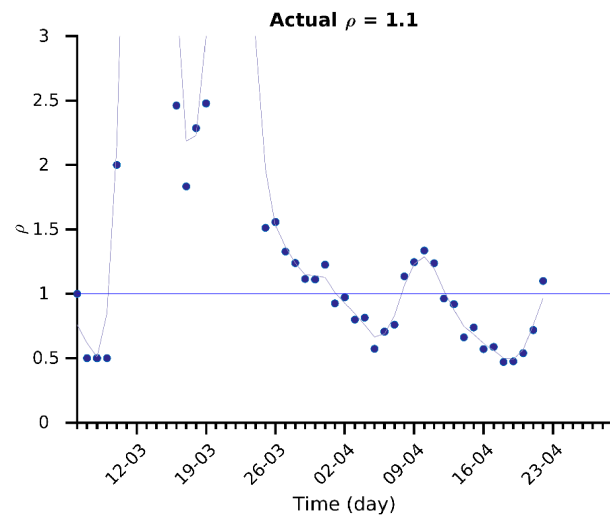
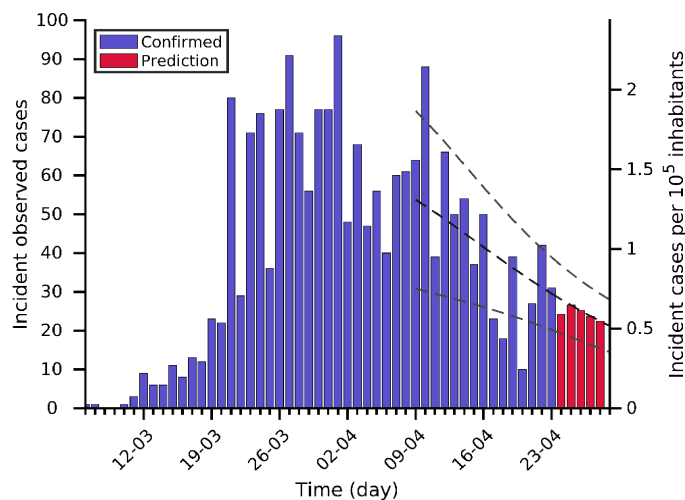
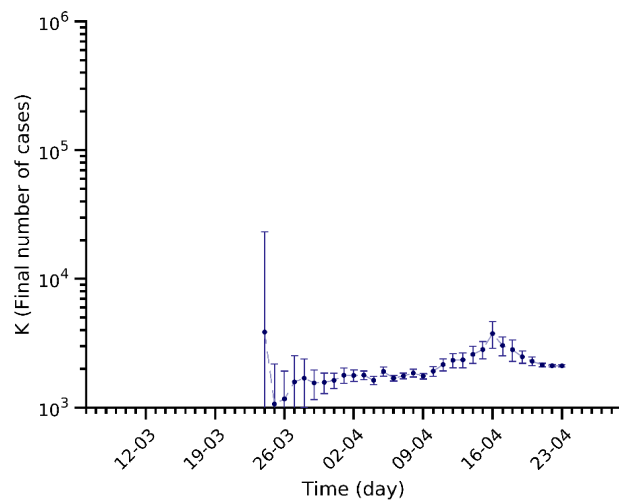
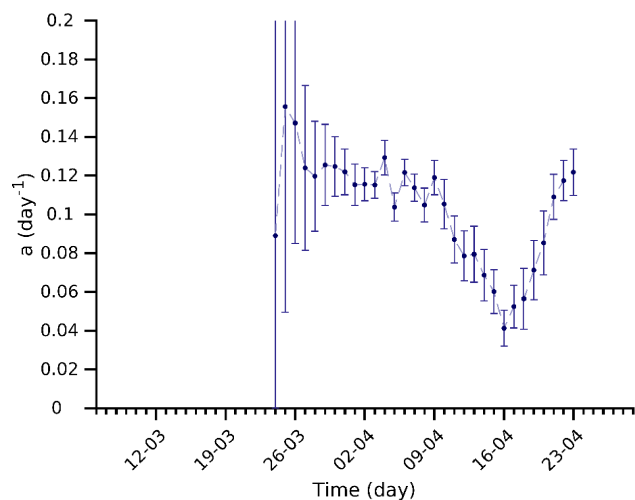
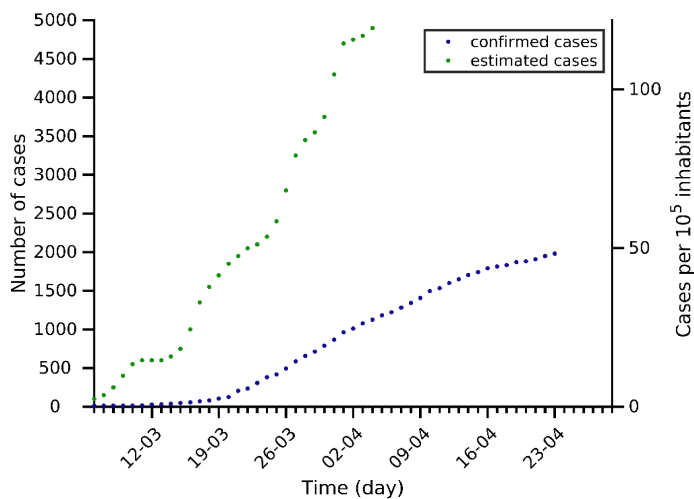
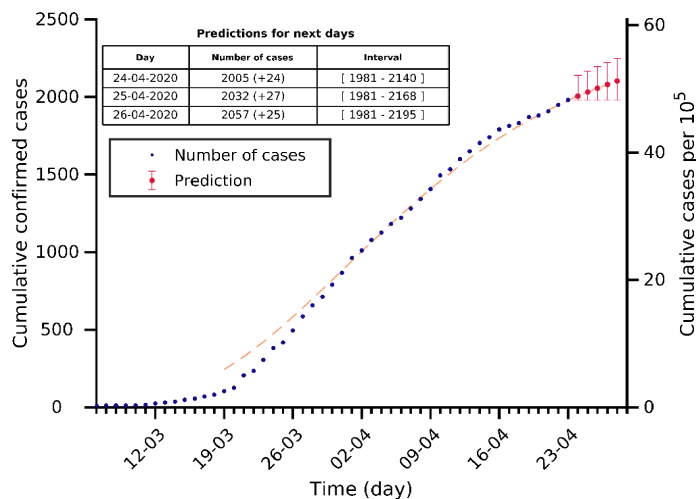
Greece 23-04-2020. Population: 10.4M. Current cumulated incidence: 24/10⁵



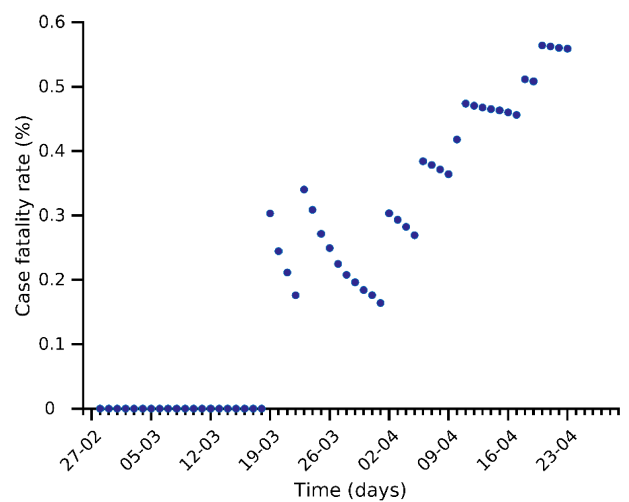
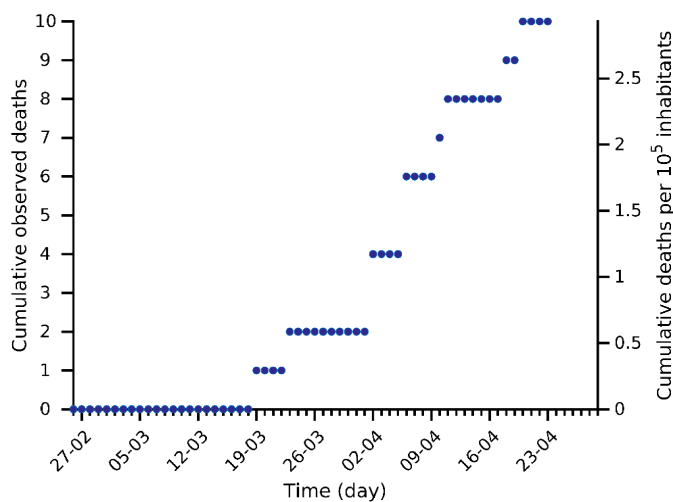
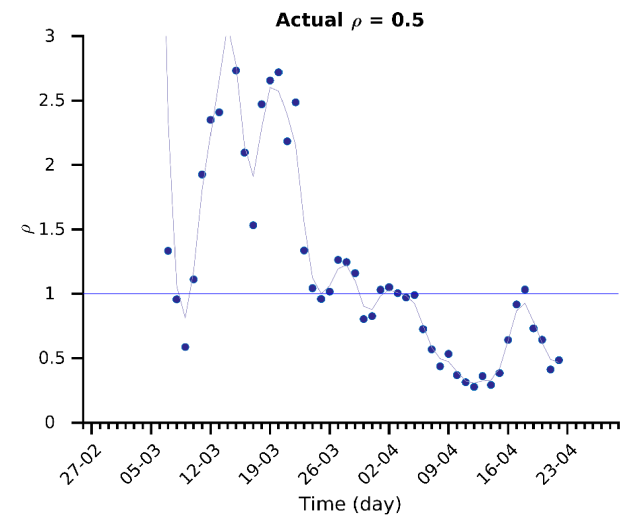
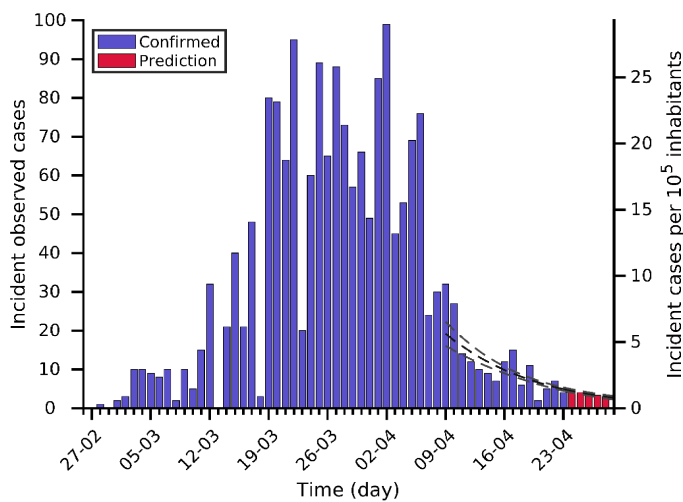
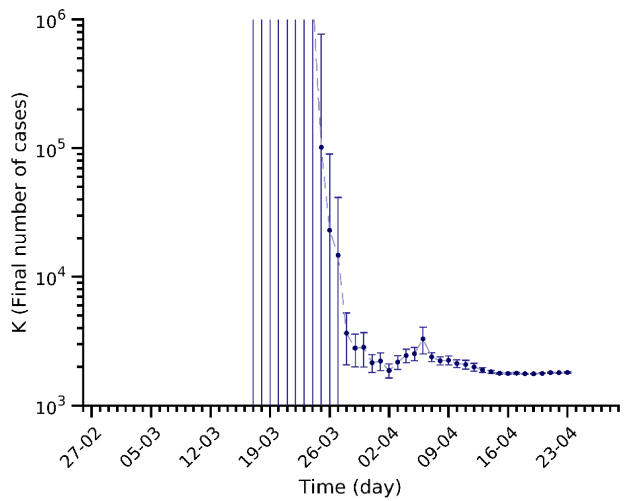
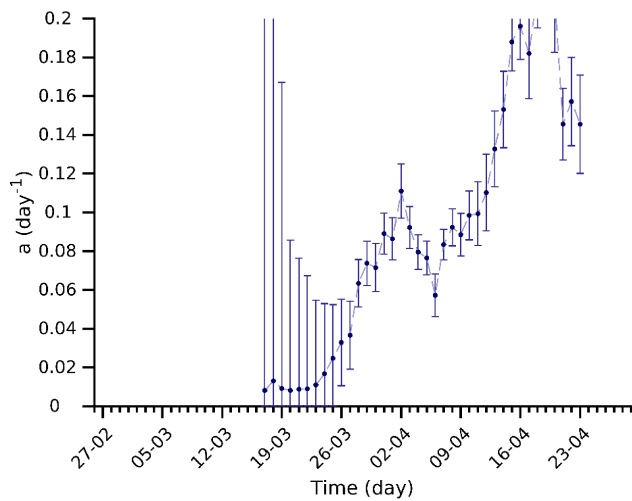
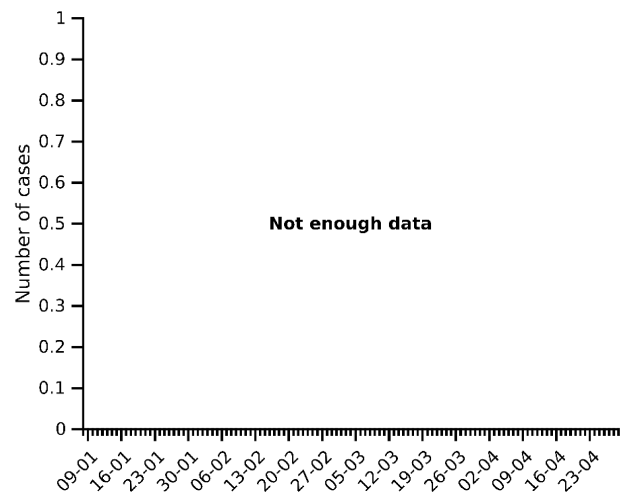
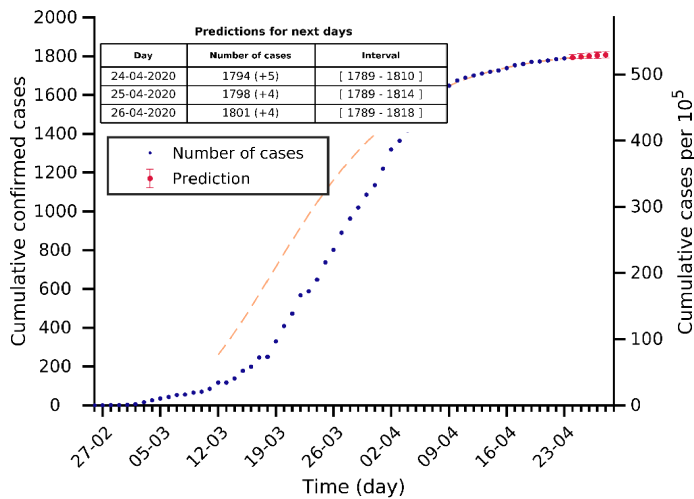
Hungary 23-04-2020. Population: 9.7M. Current cumulated incidence: 25/10⁵



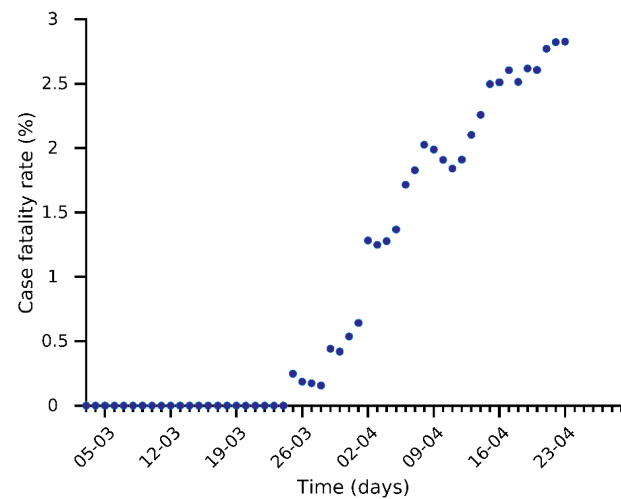
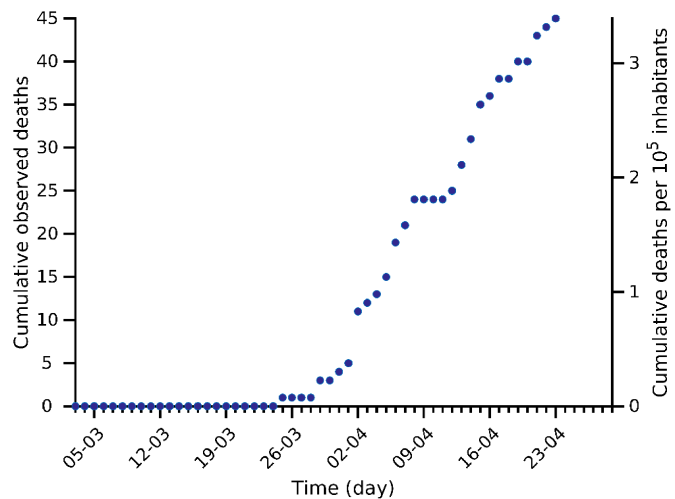
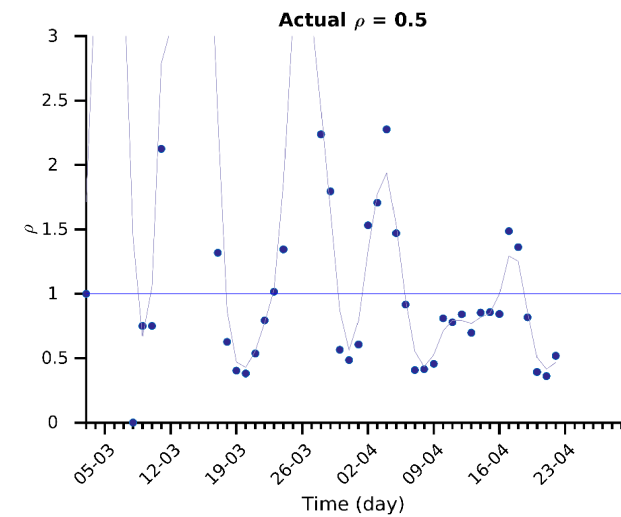
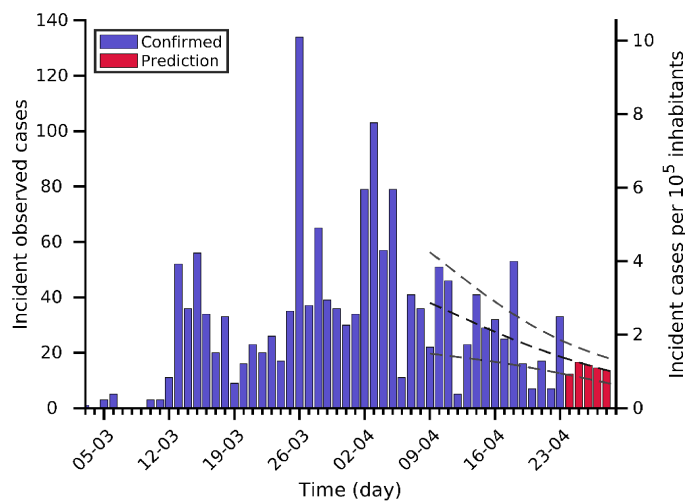
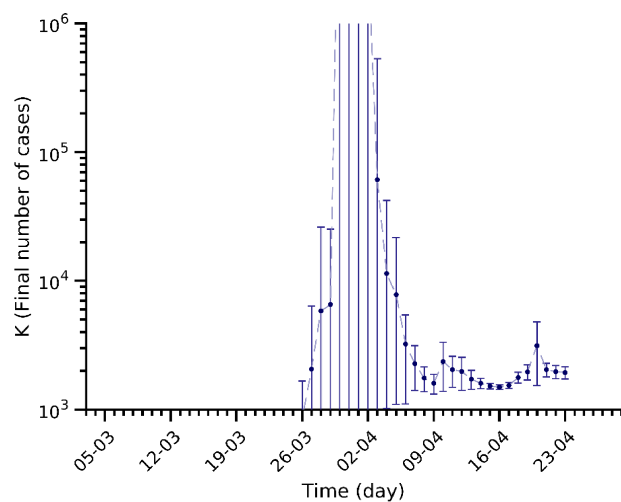
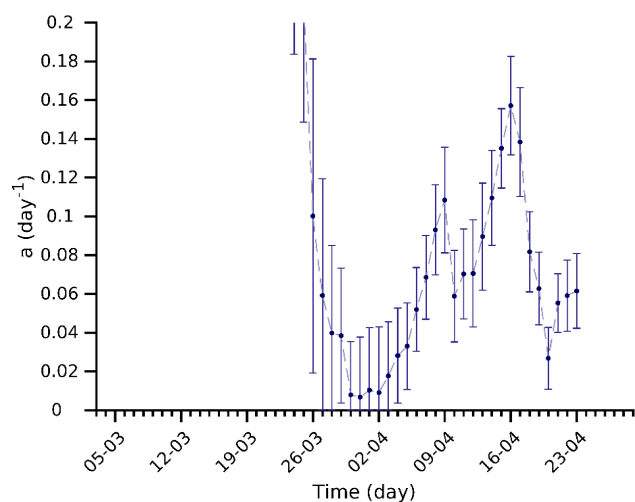
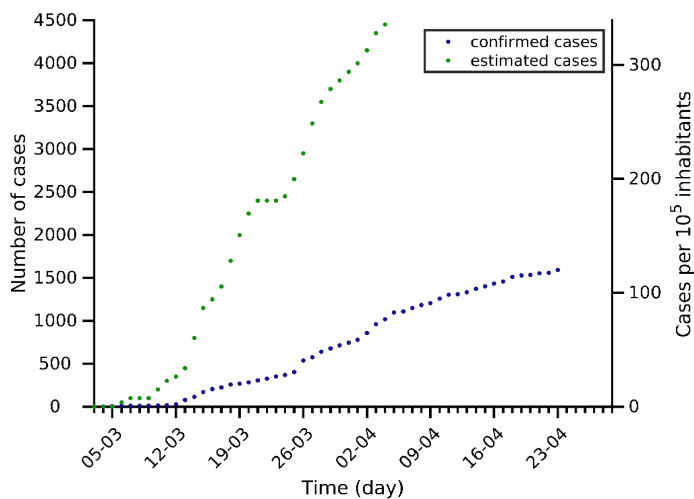
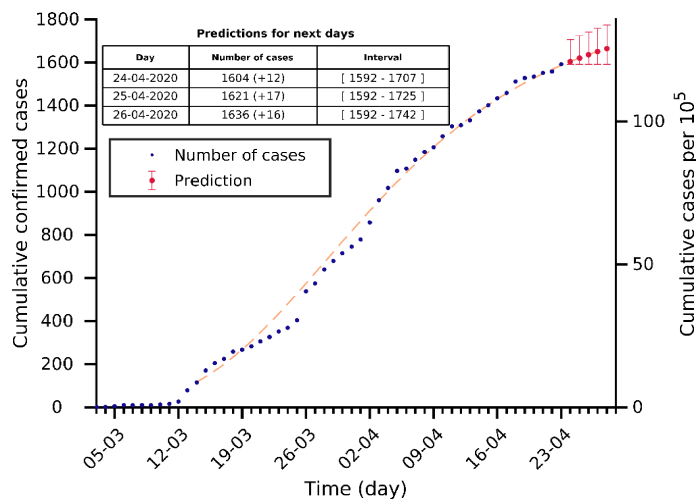
Croatia 23-04-2020. Population: 4.1M. Current cumulated incidence: 48/10⁵



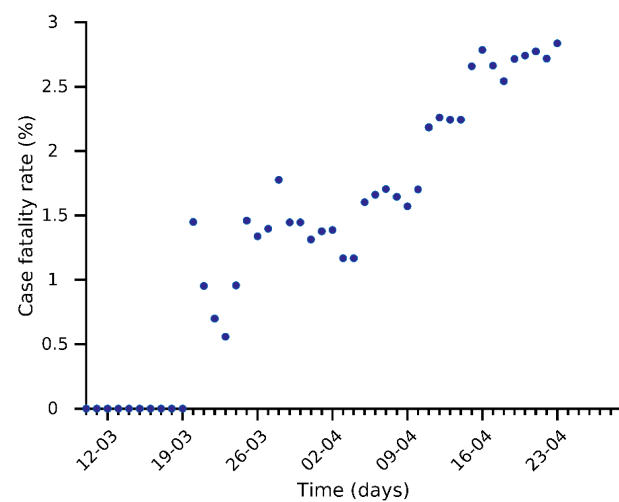
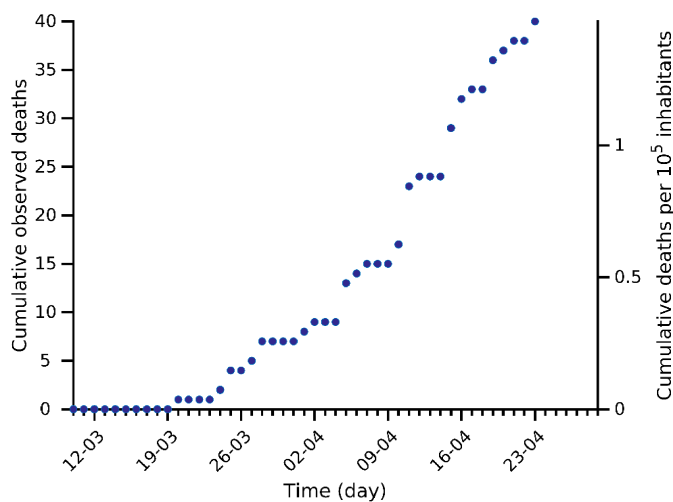
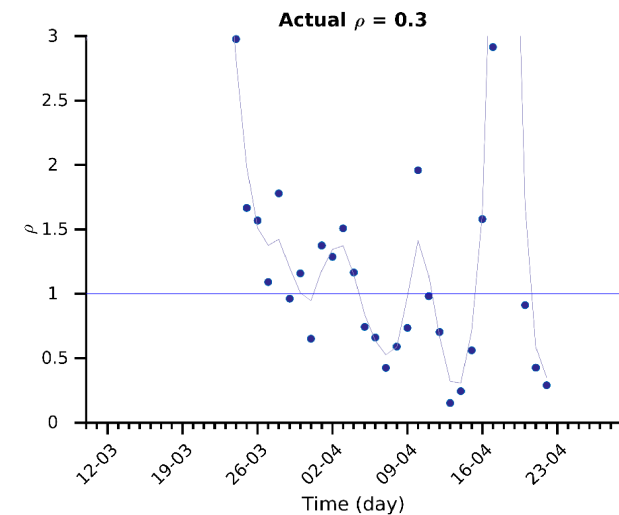
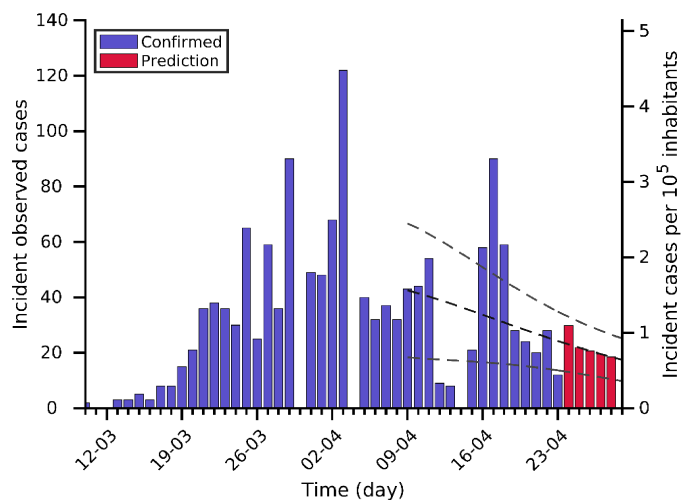
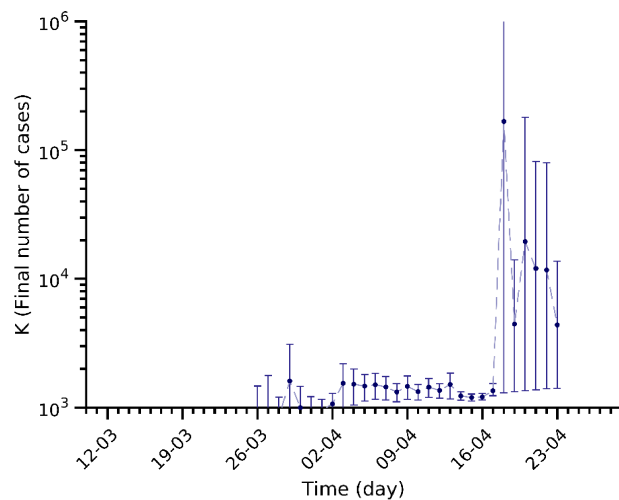
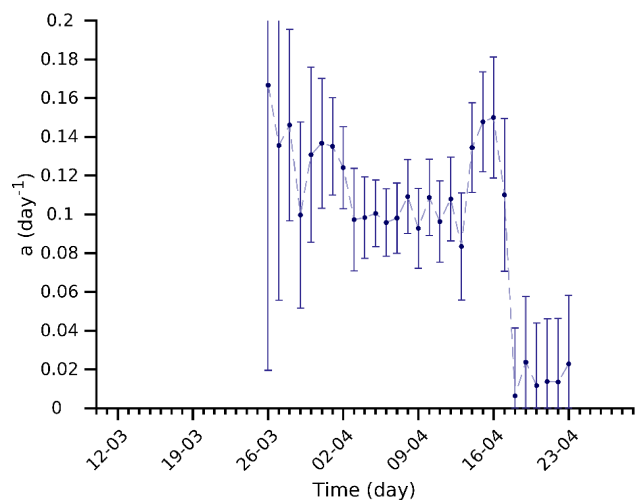
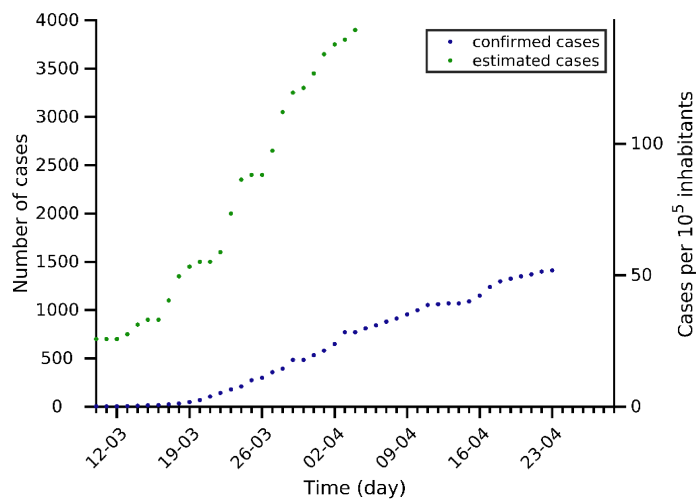
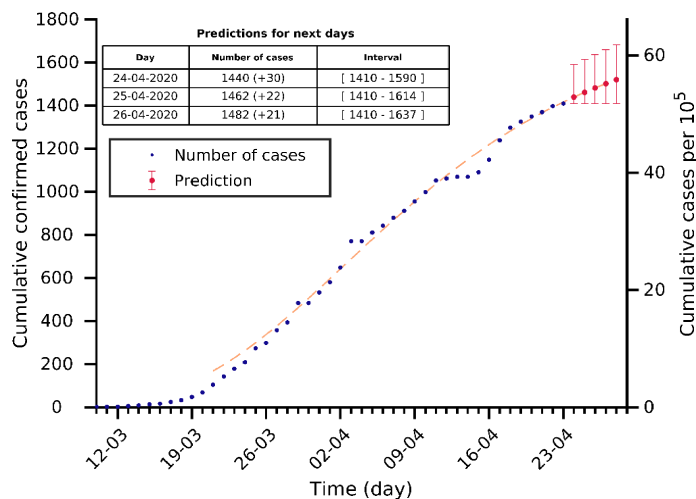
Iceland 23-04-2020. Population: 0.3M. Current cumulated incidence: 524/10⁵



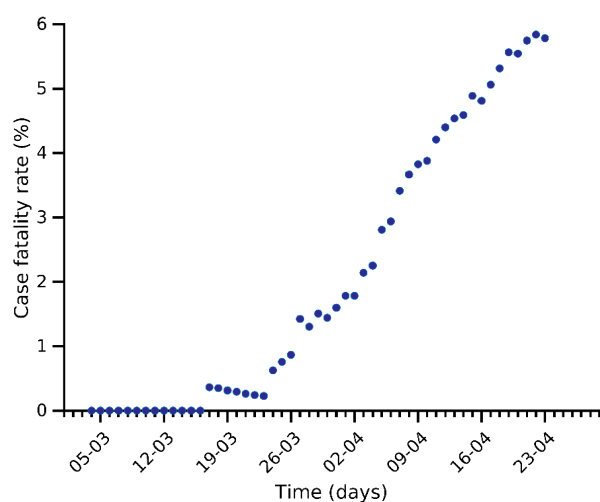
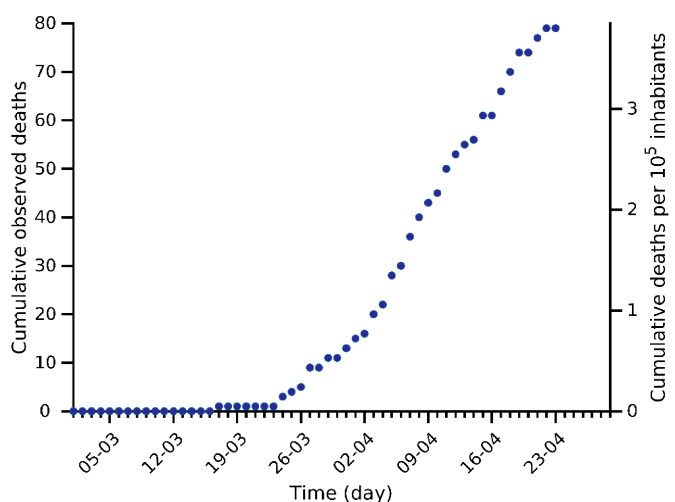
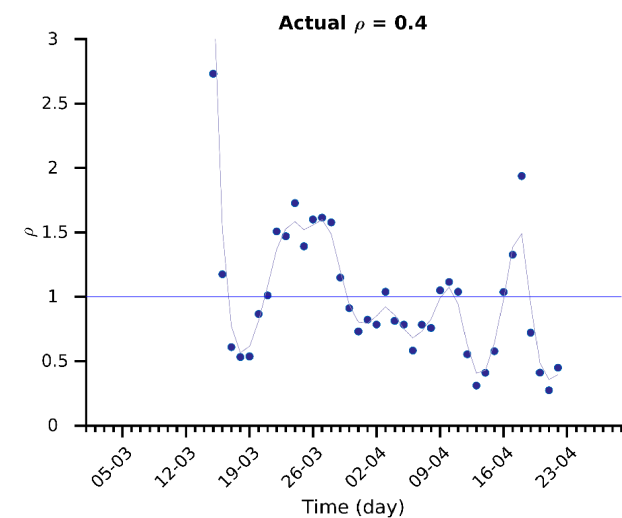
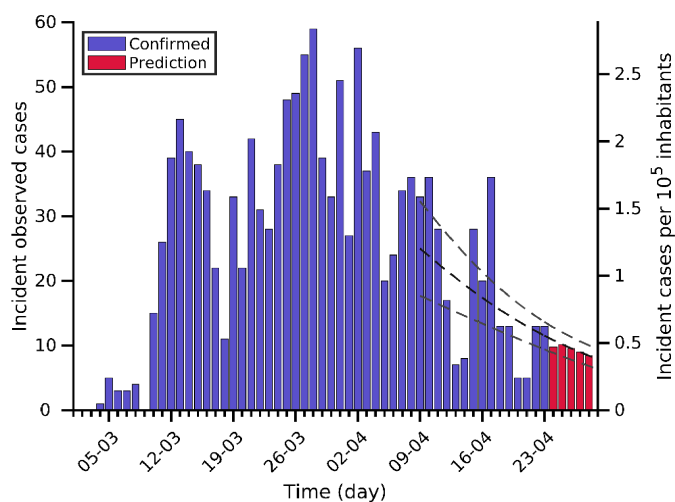
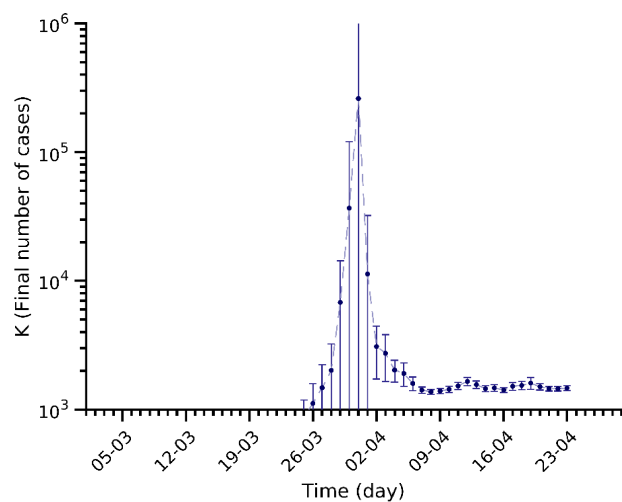
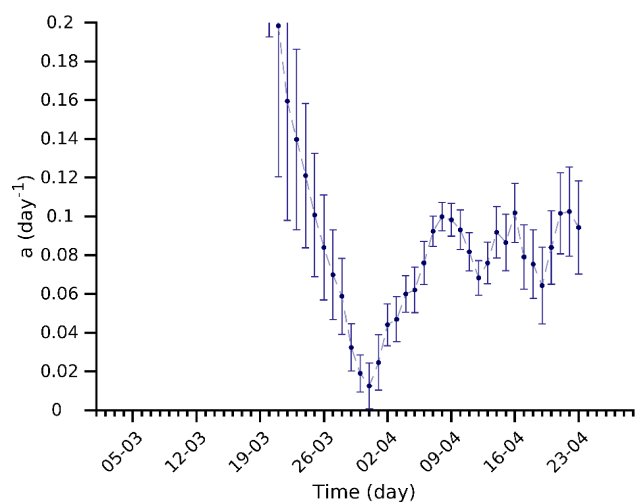
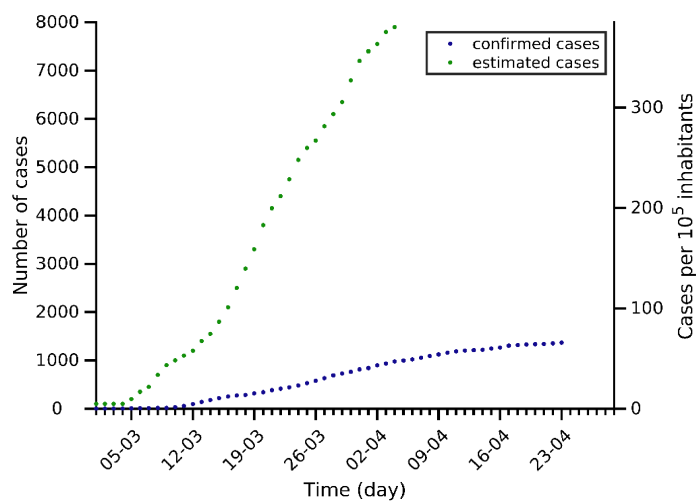
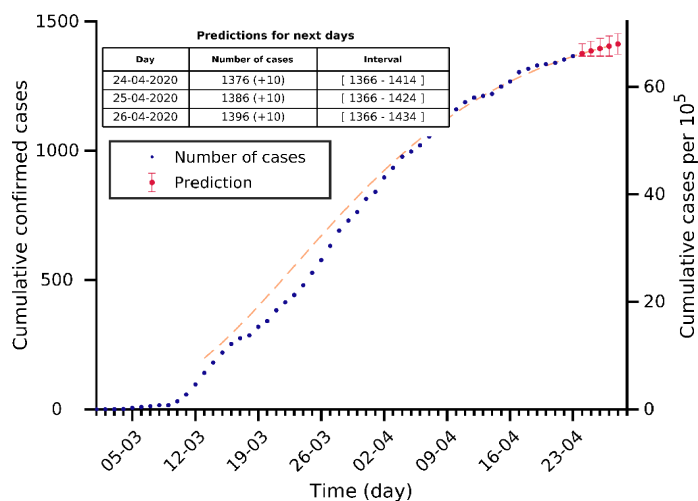
Estonia 23-04-2020. Population: 1.3M. Current cumulated incidence: 120/10⁵



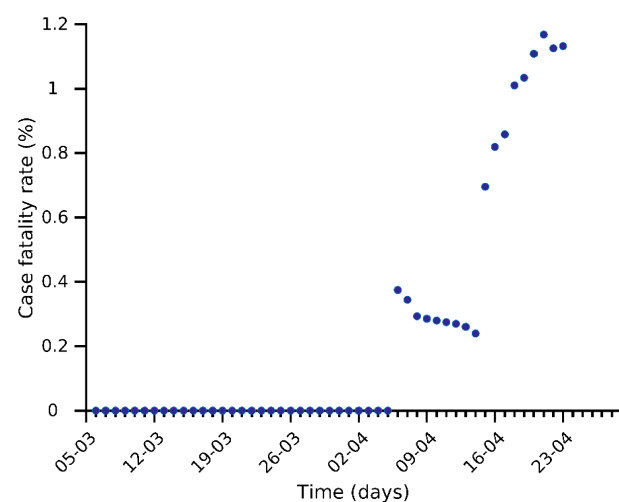
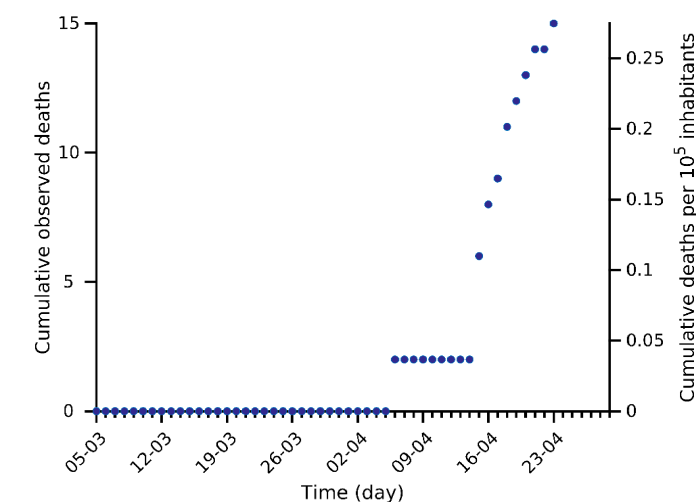
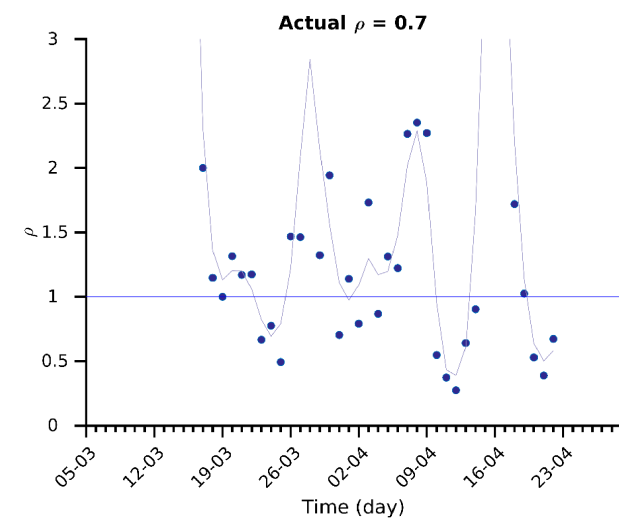
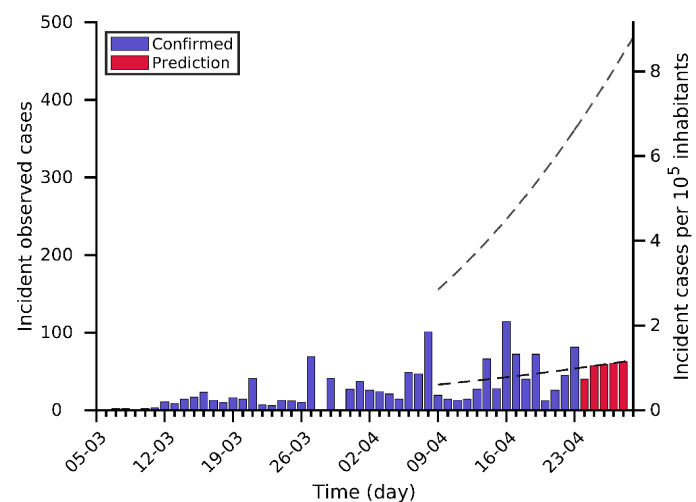
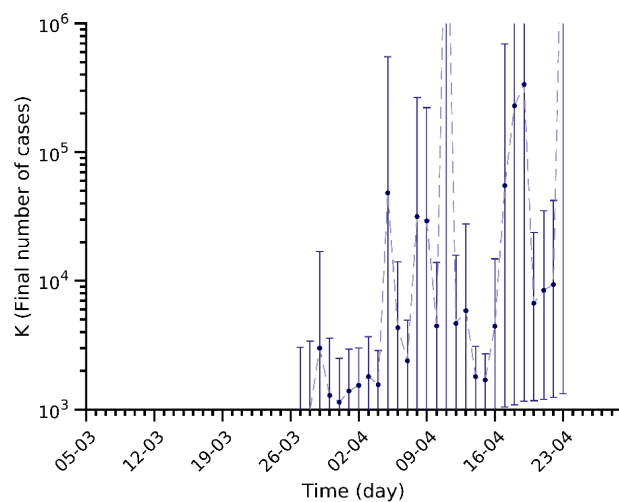
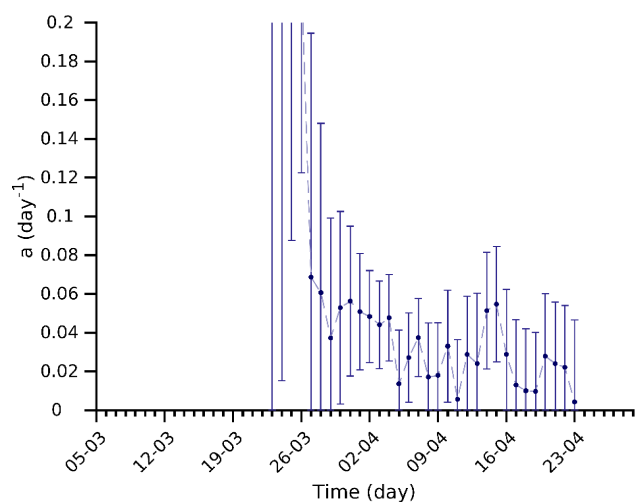
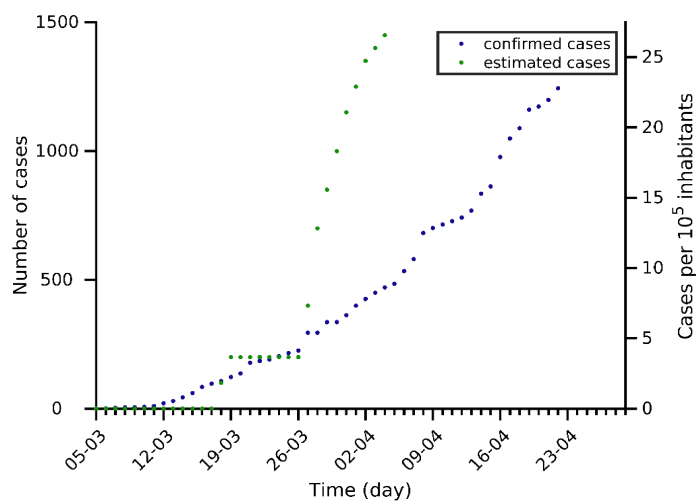
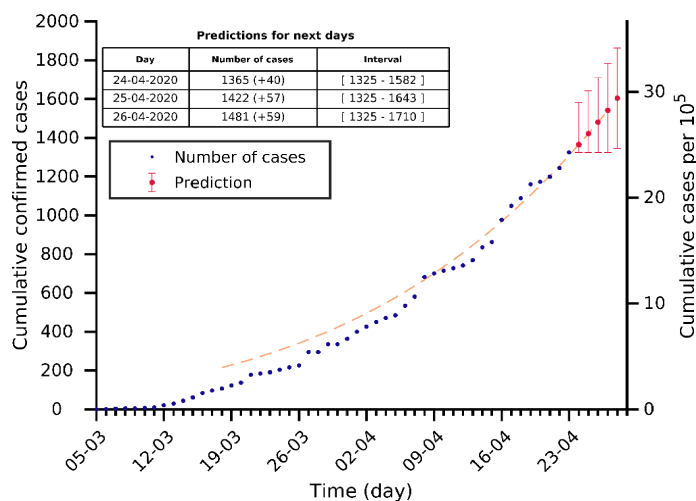
Lithuania 23-04-2020. Population: 2.7M. Current cumulated incidence: 52/10⁵



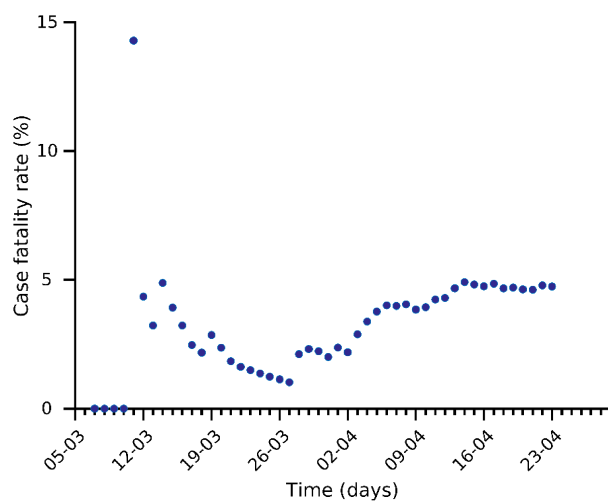
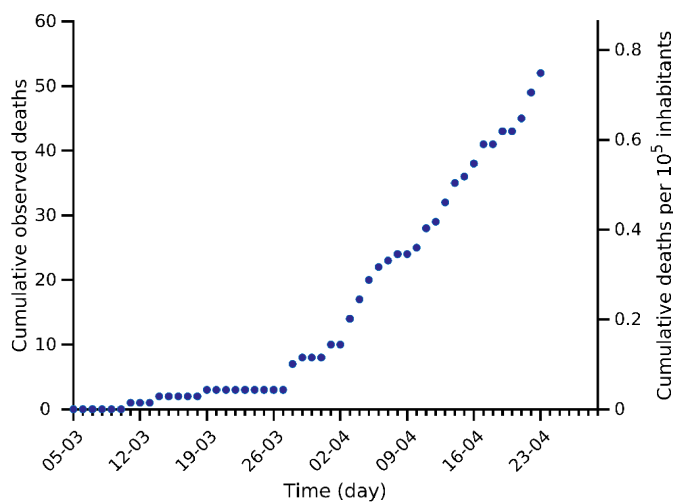
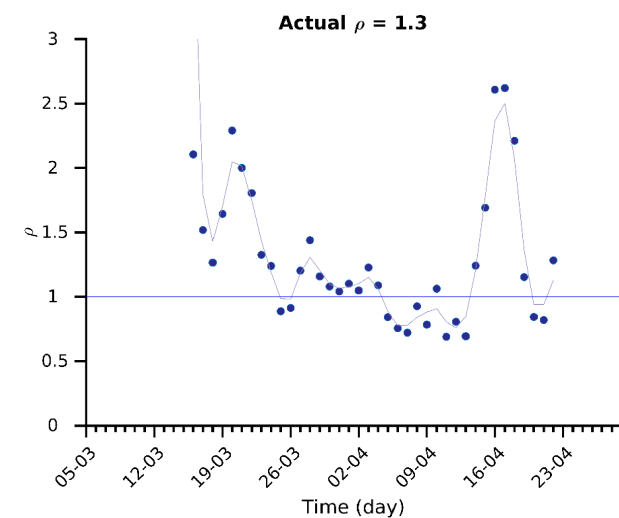
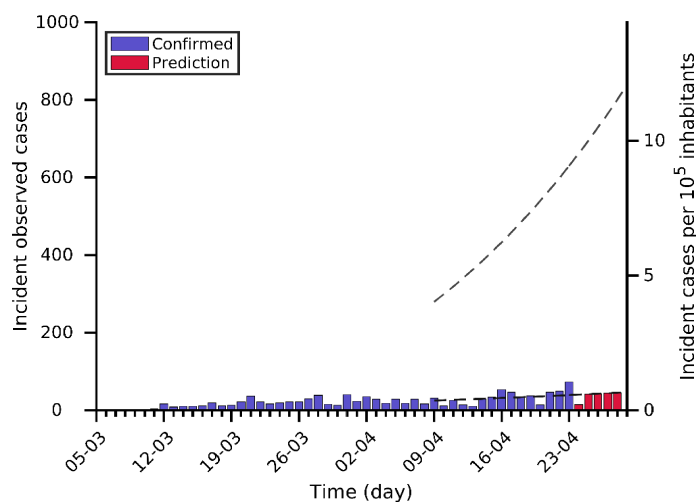
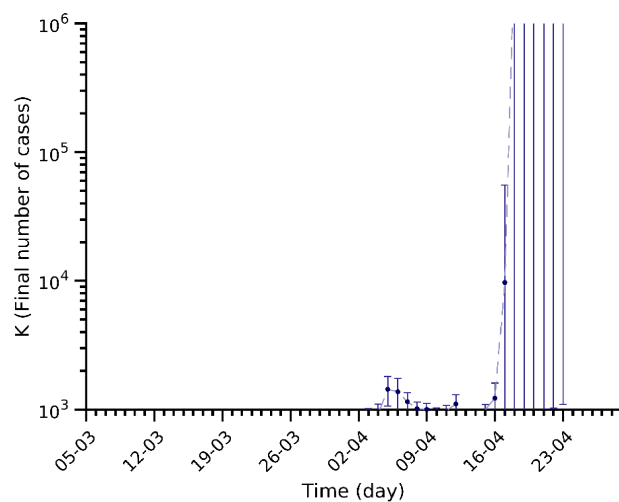
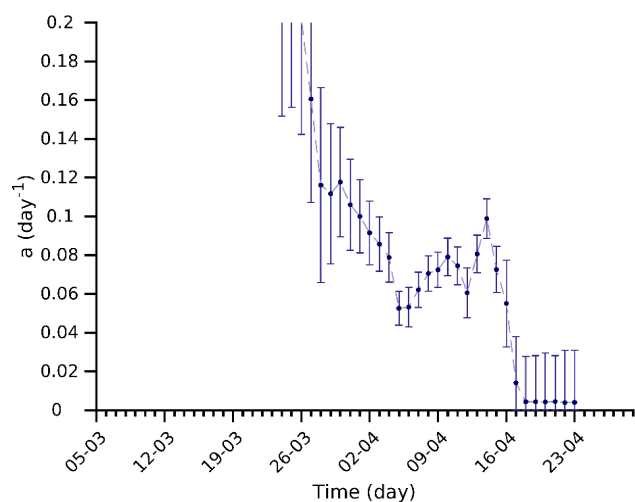
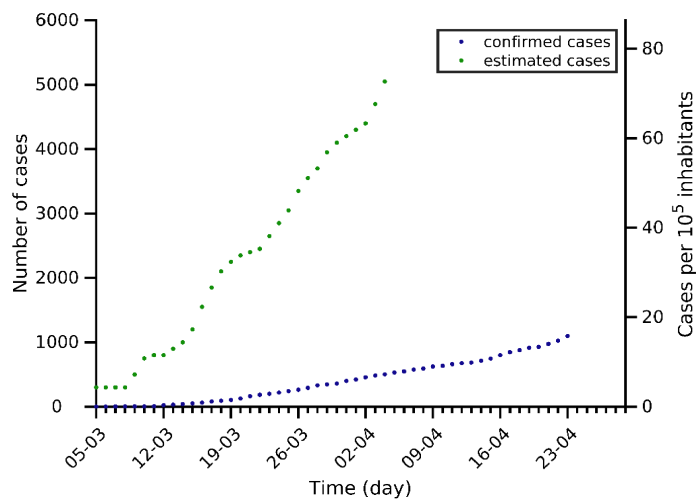
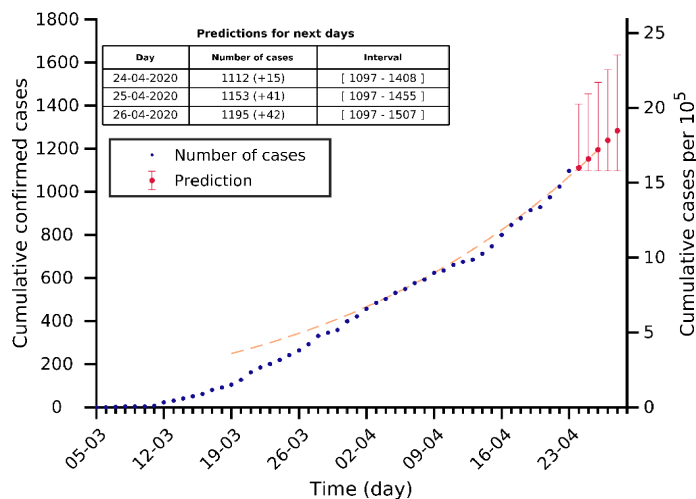
Slovenia 23-04-2020. Population: 2.1M. Current cumulated incidence: 66/10⁵



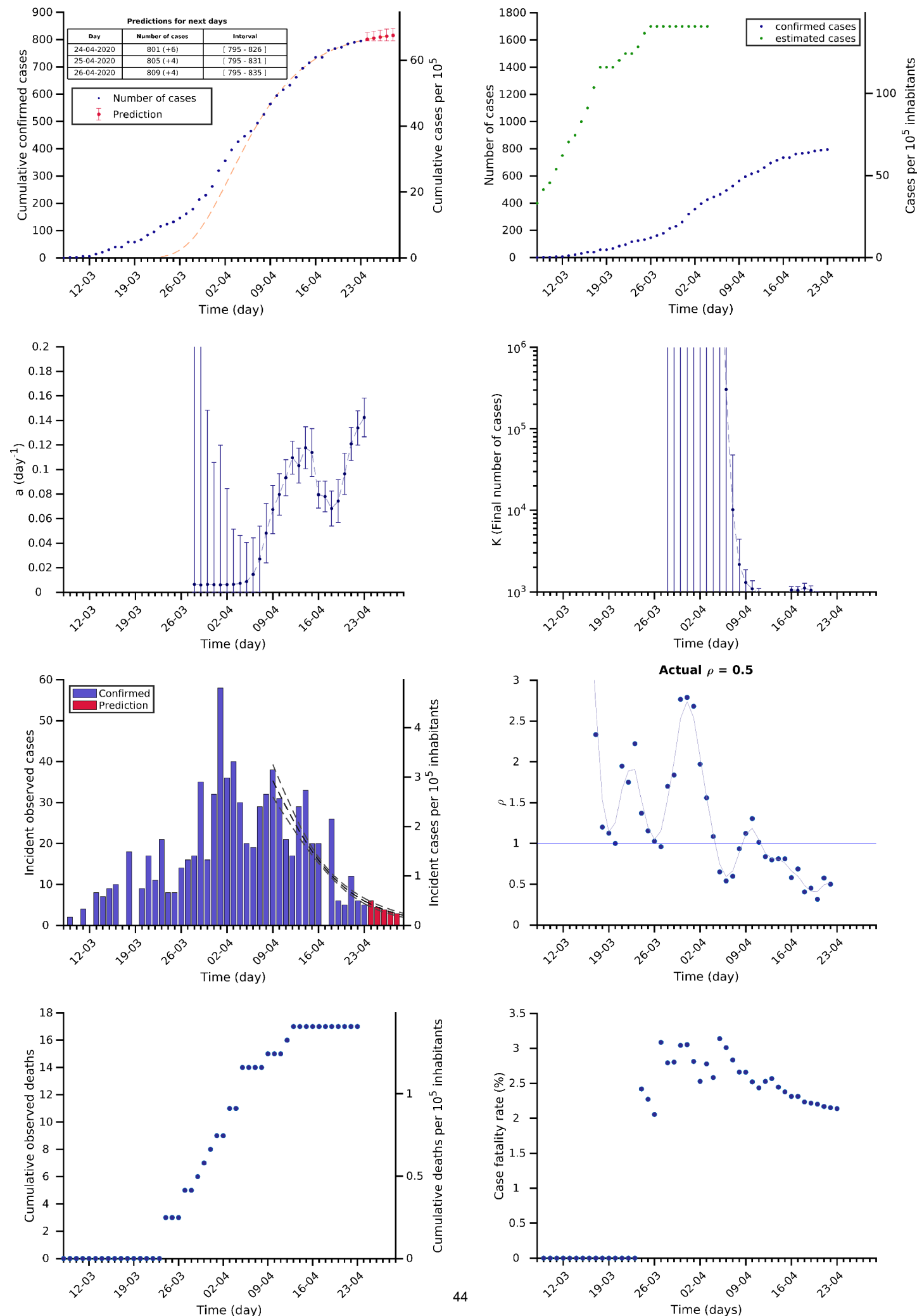
Slovakia 23-04-2020. Population: 5.5M. Current cumulated incidence: $24/10^5$



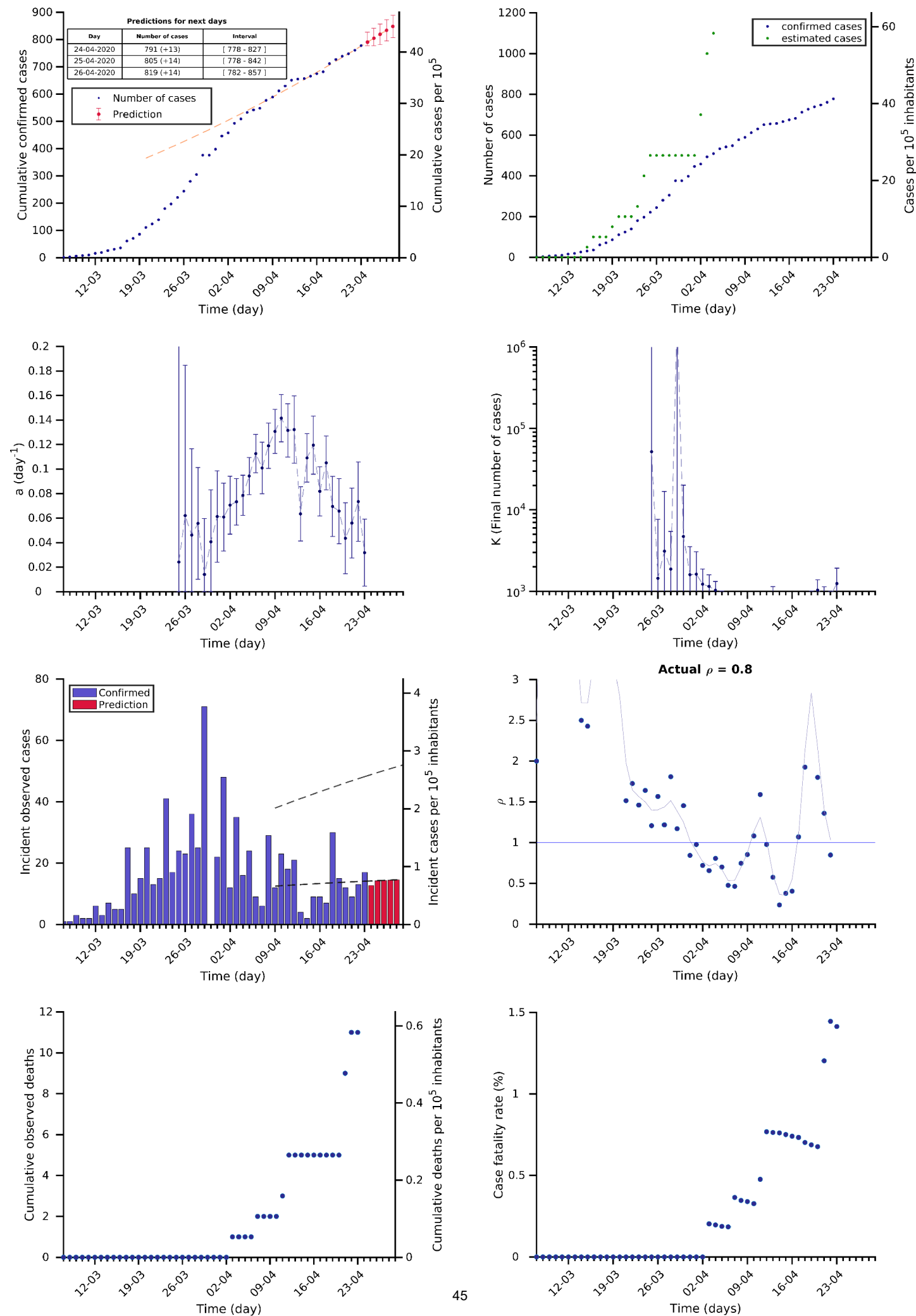
Bulgaria 23-04-2020. Population: 6.9M. Current cumulated incidence: 16/10⁵



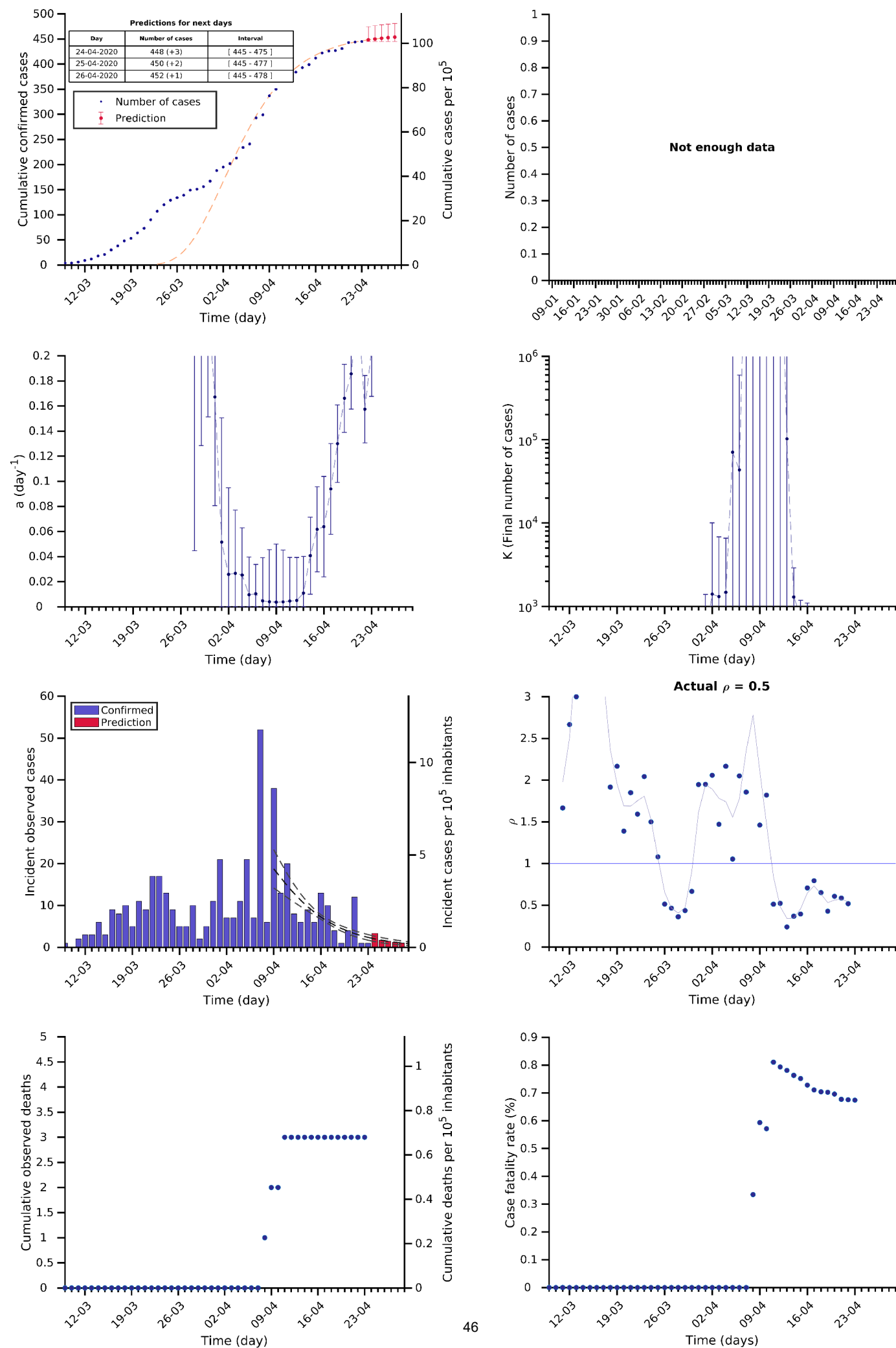
Cyprus 23-04-2020. Population: 1.2M. Current cumulated incidence: 66/10⁵



Latvia 23-04-2020. Population: 1.9M. Current cumulated incidence: 41/10⁵



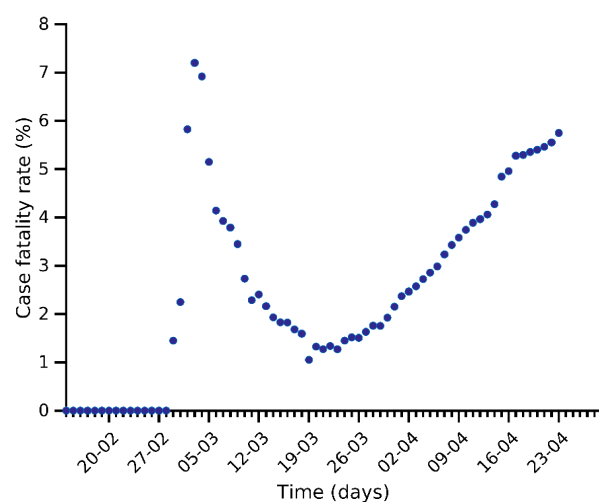
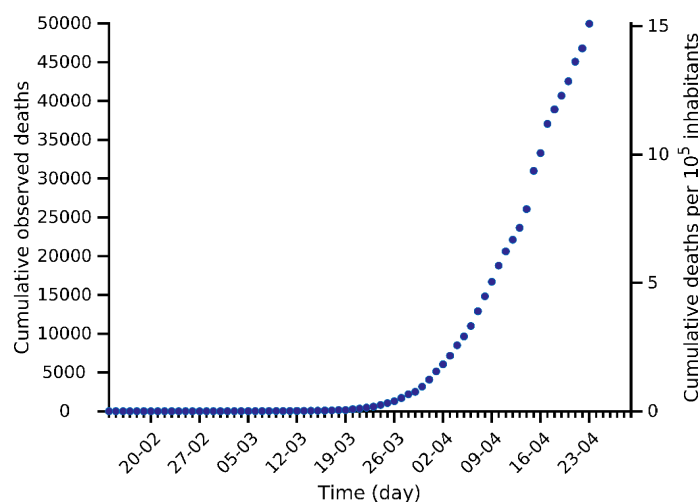
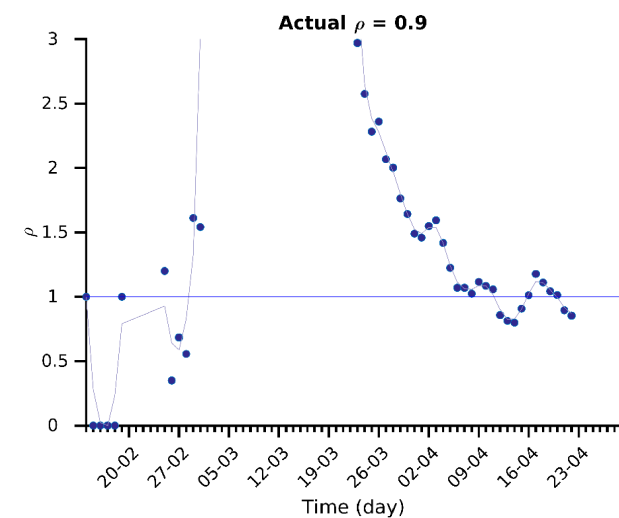
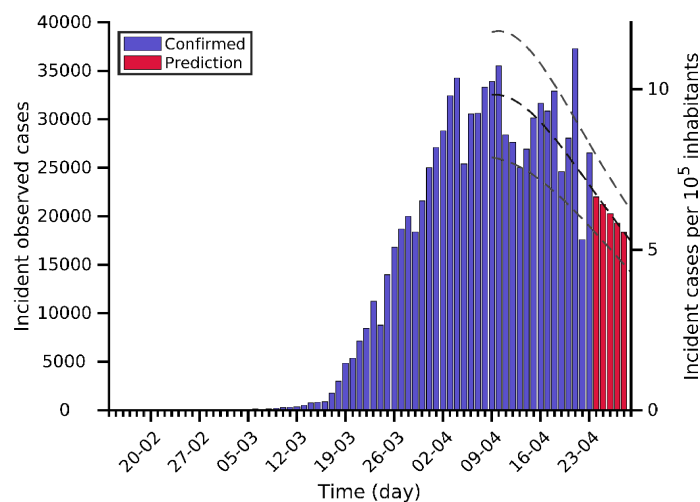
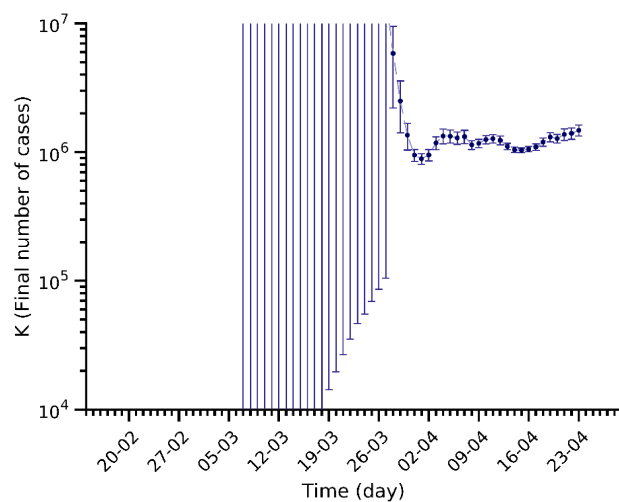
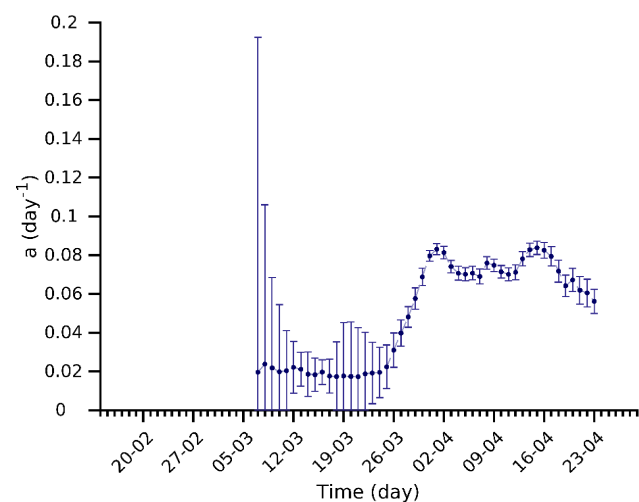
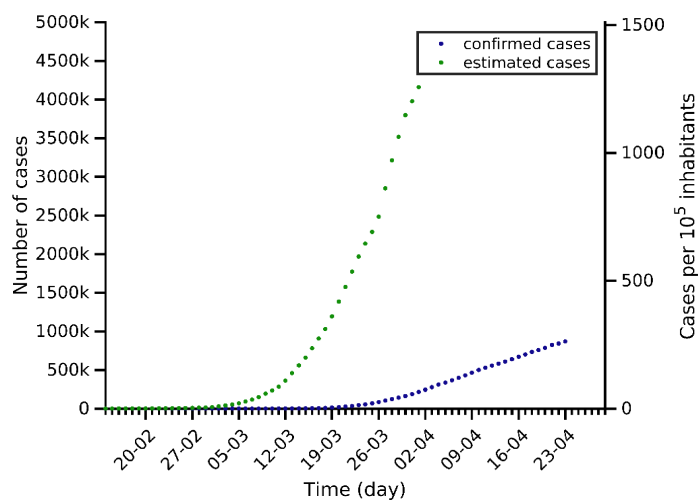
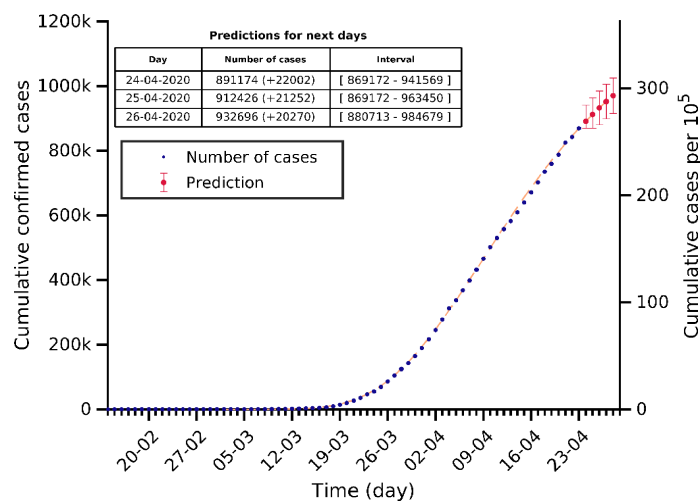
Malta 23-04-2020. Population: 0.4M. Current cumulated incidence: 101/10⁵



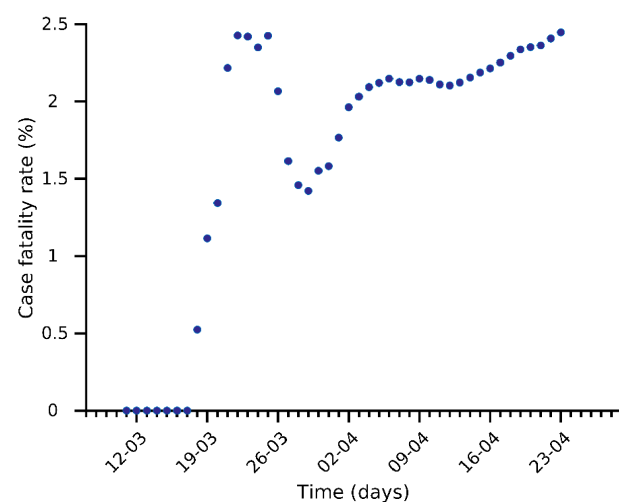
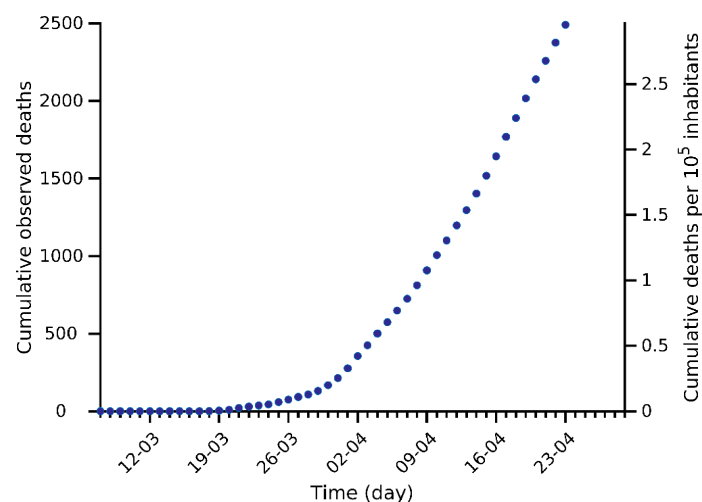
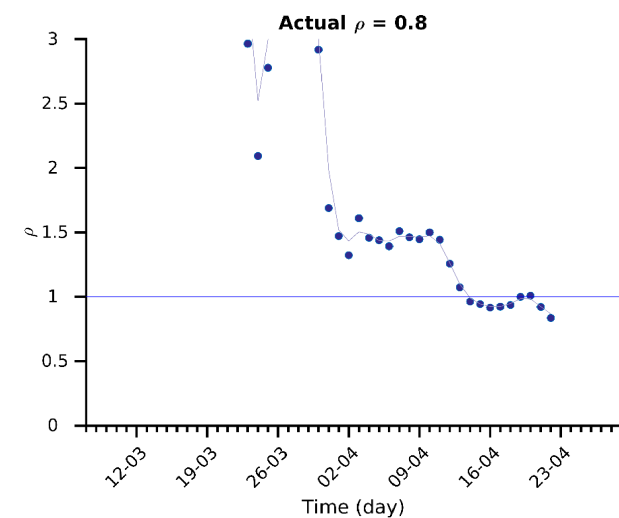
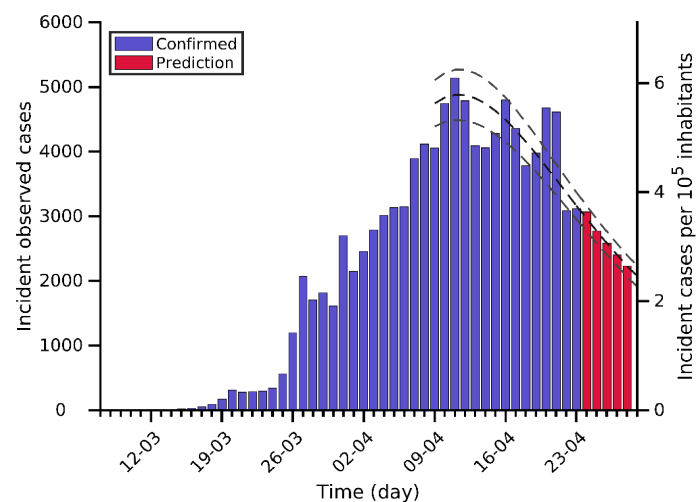
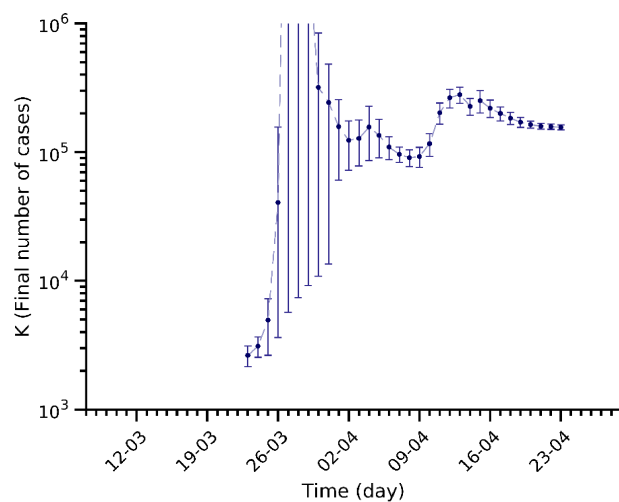
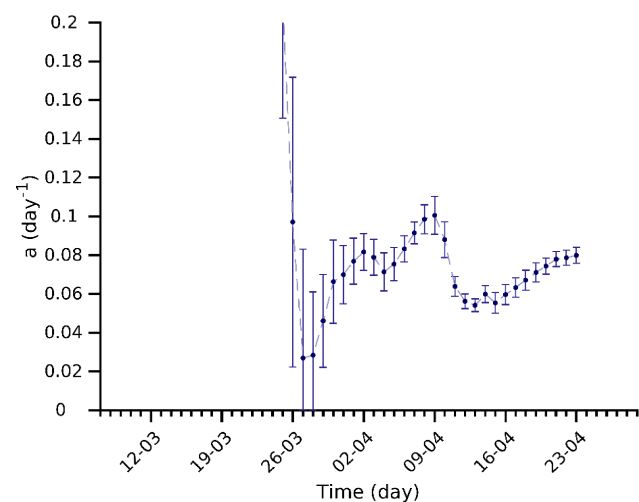
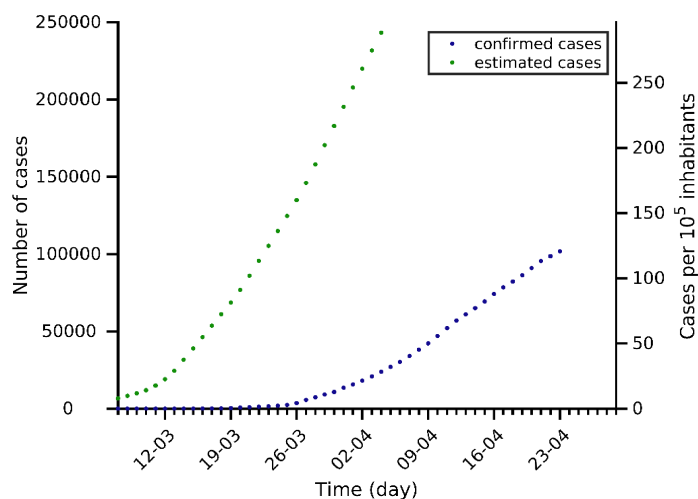
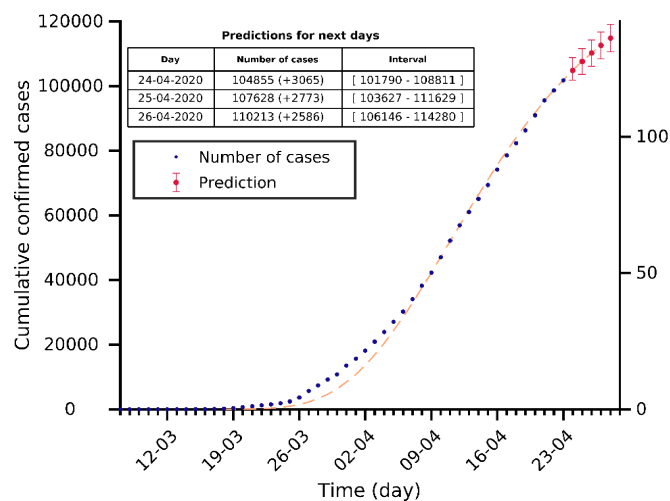
(2) Analysis and prediction of COVID-19 for other countries

Data obtained from <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

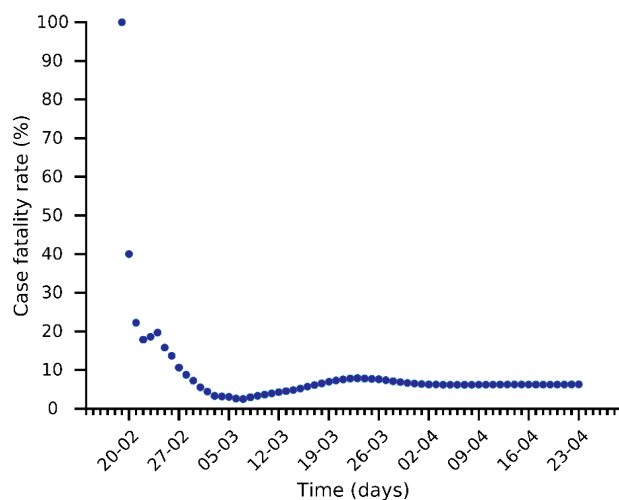
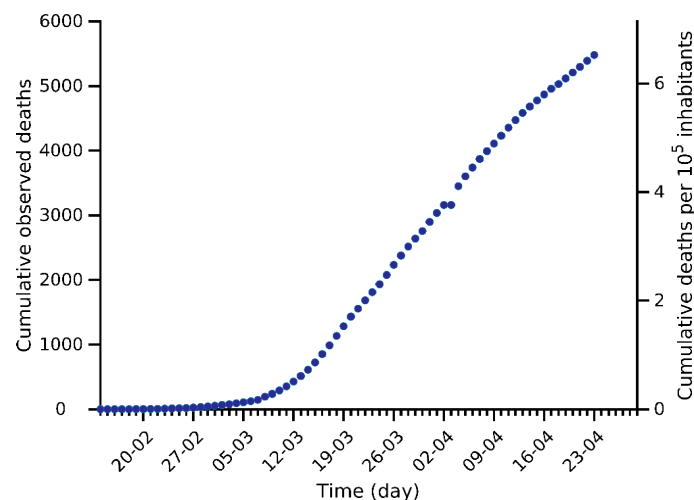
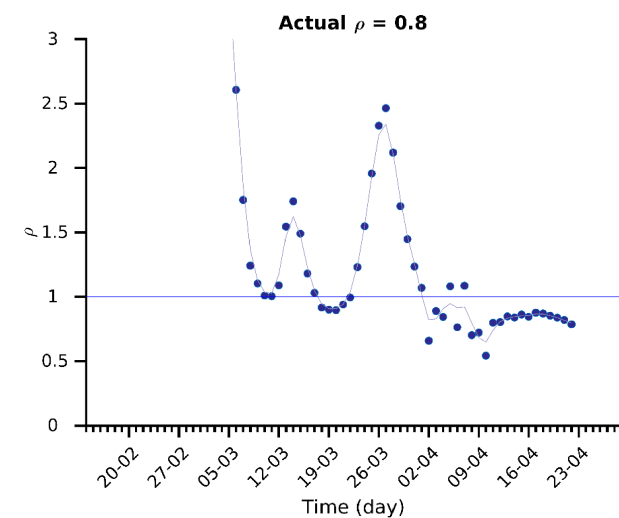
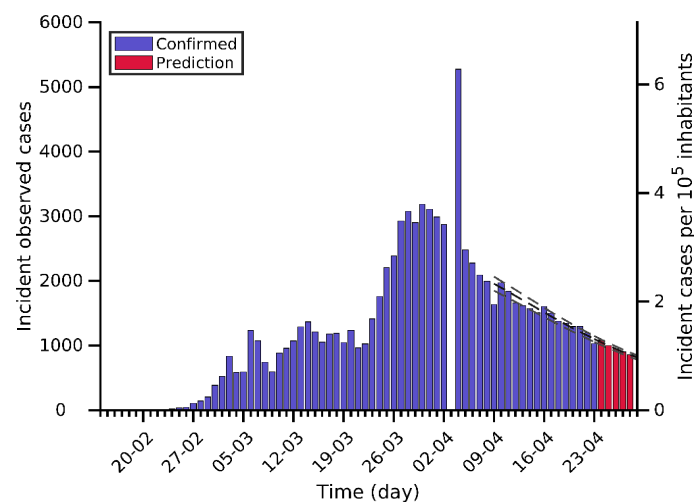
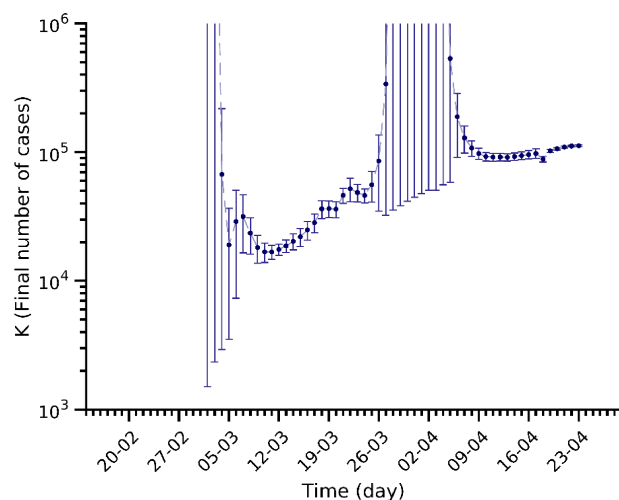
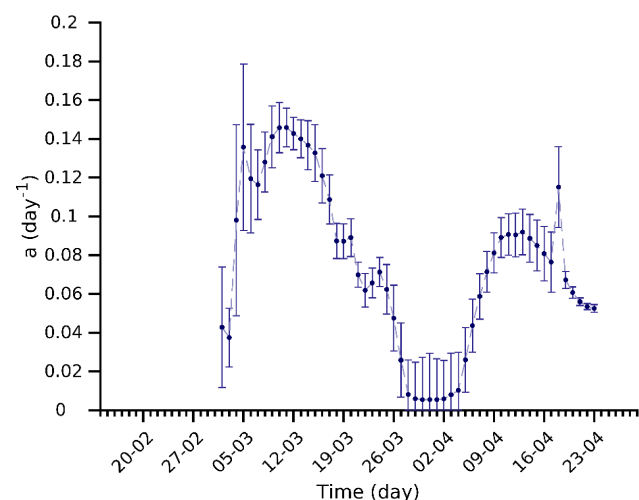
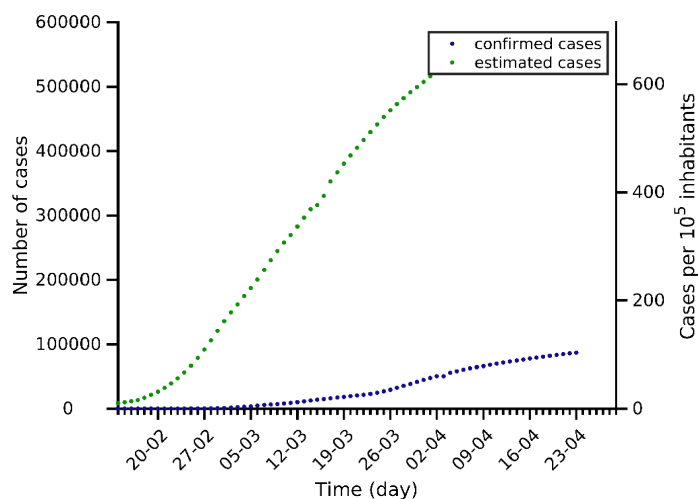
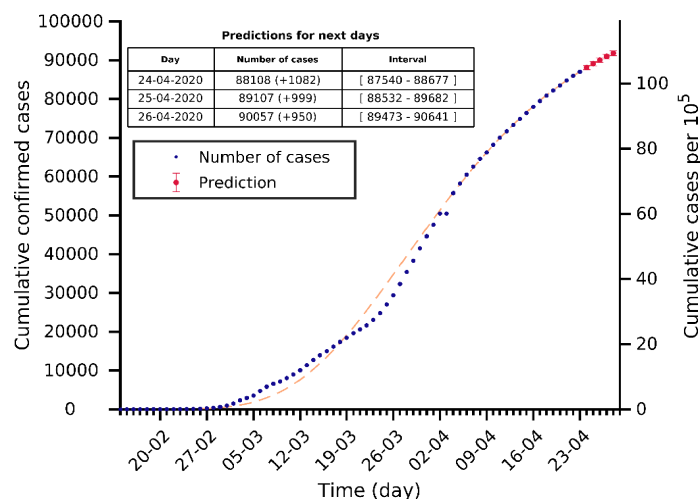
USA 23-04-2020. Population: 331.0M. Current cumulated incidence: 263/10⁵



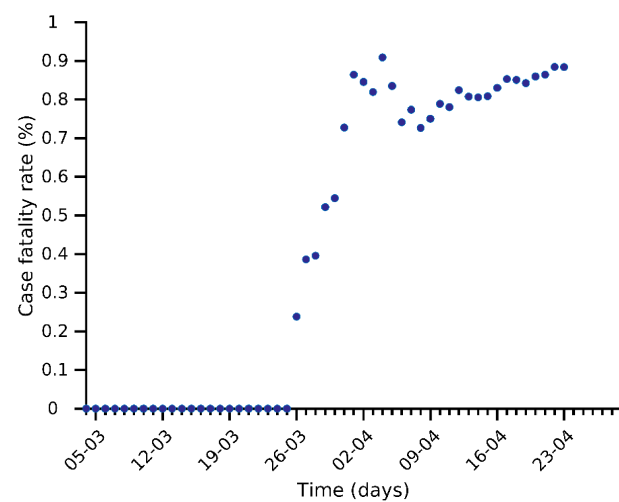
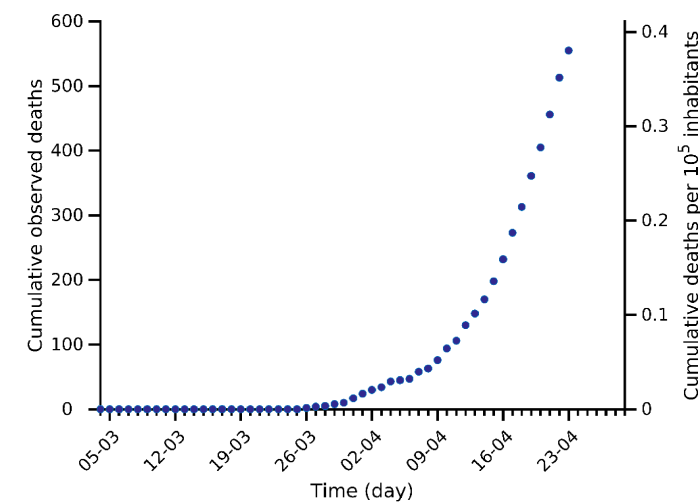
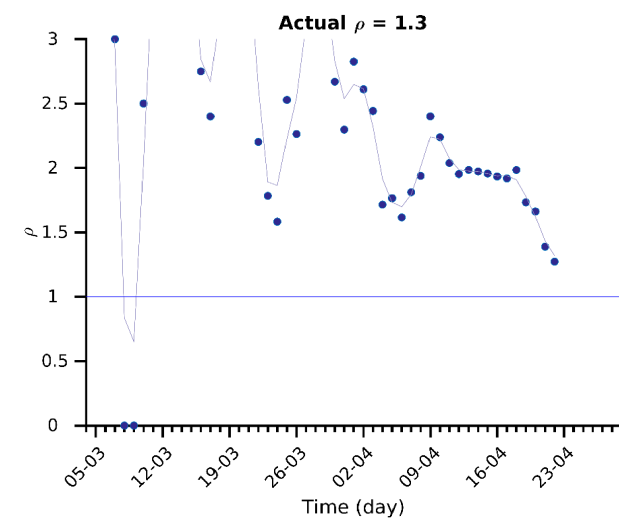
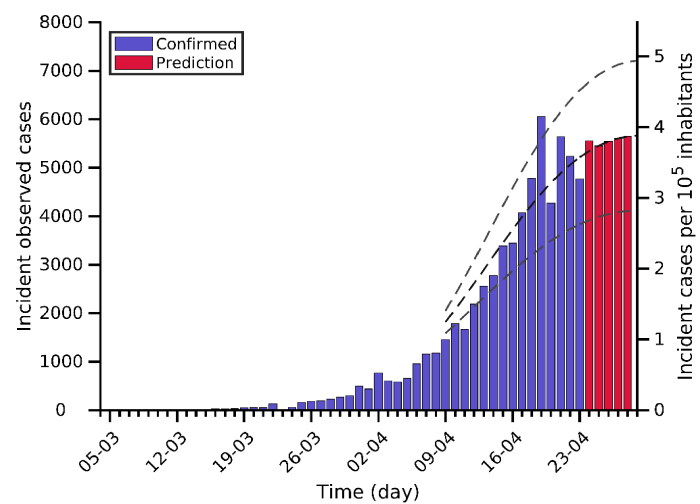
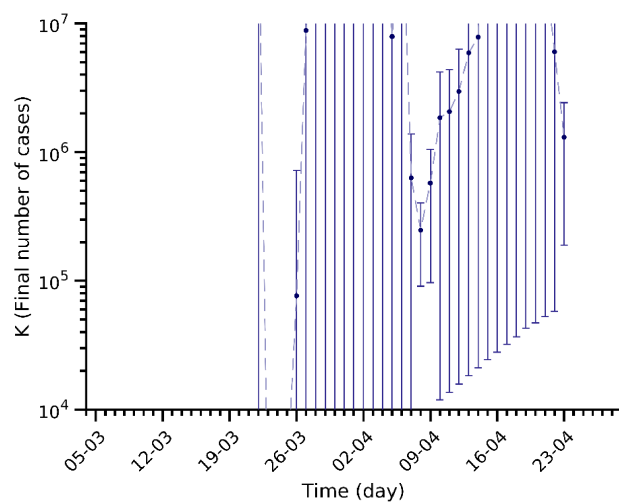
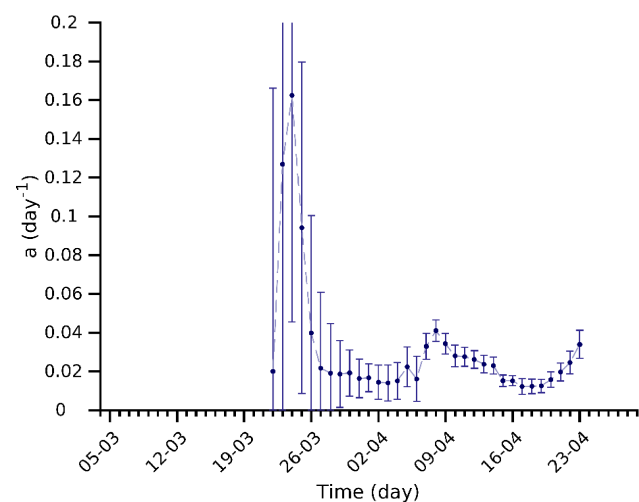
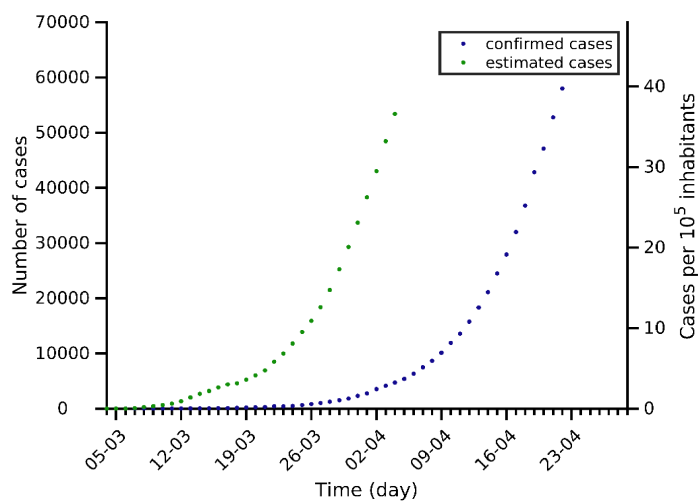
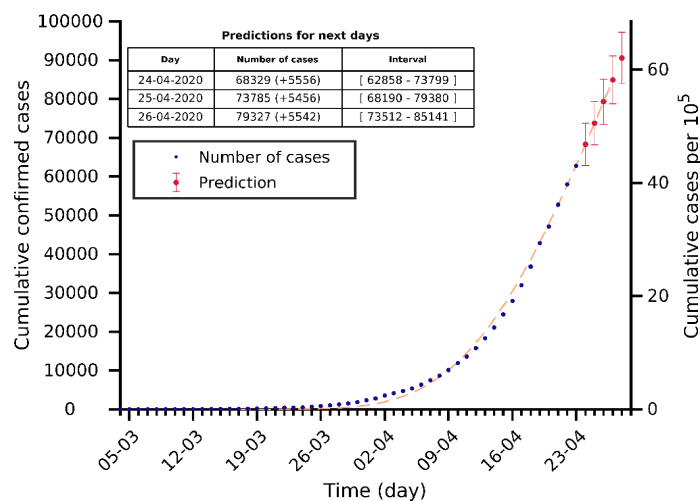
Turkey 23-04-2020. Population: 84.3M. Current cumulated incidence: 121/10⁵



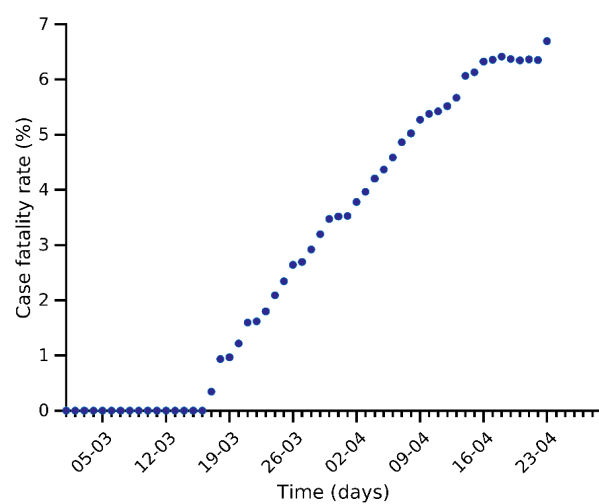
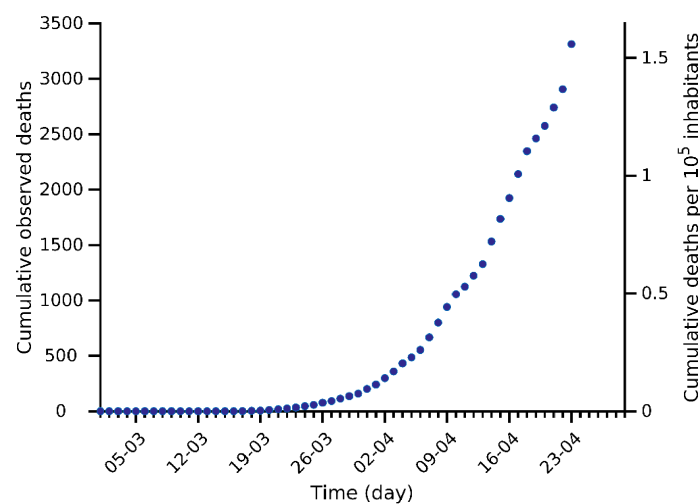
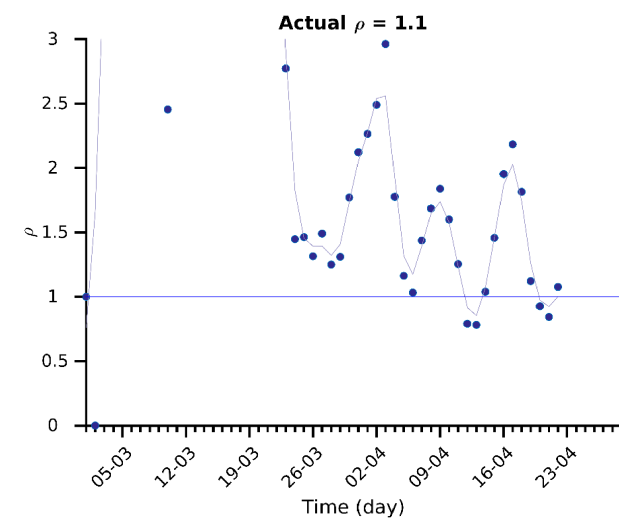
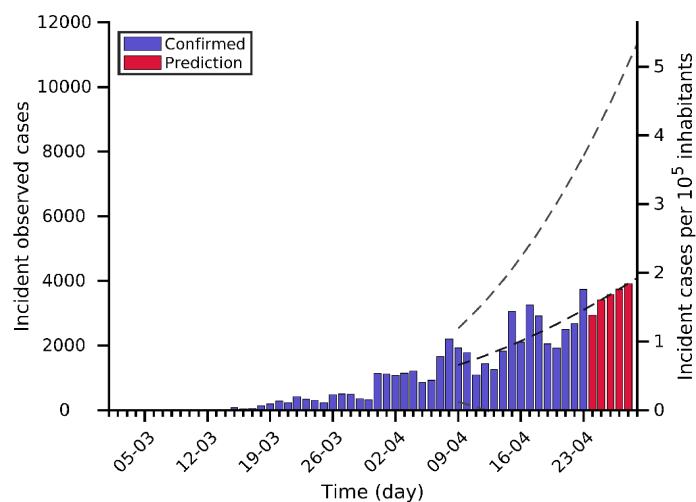
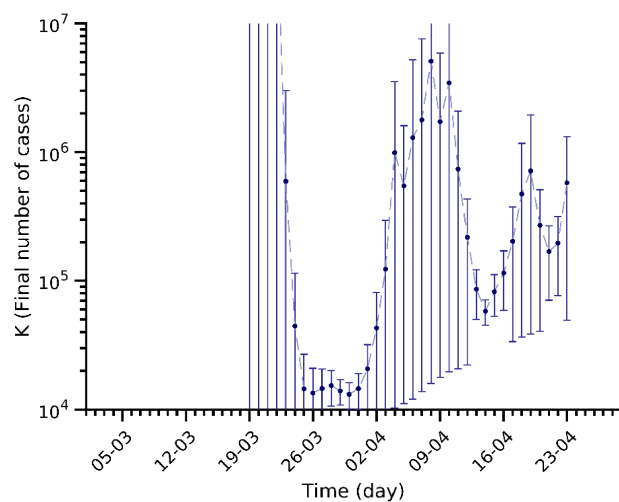
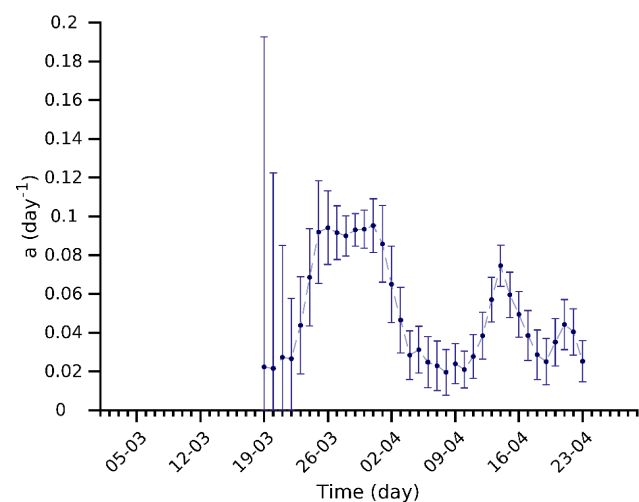
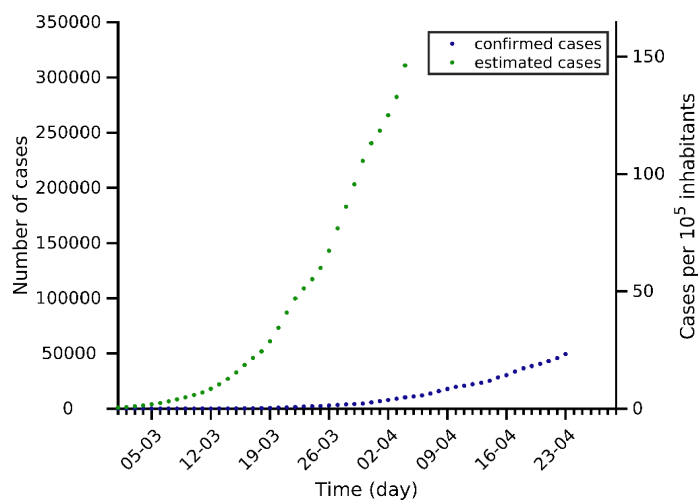
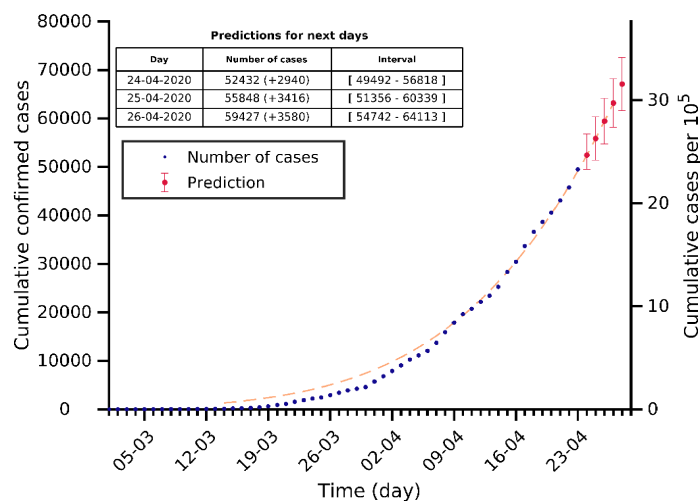
Iran 23-04-2020. Population: 84.0M. Current cumulated incidence: 104/10⁵



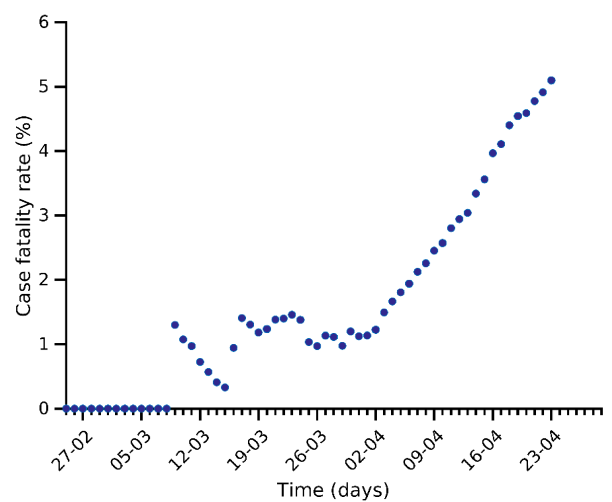
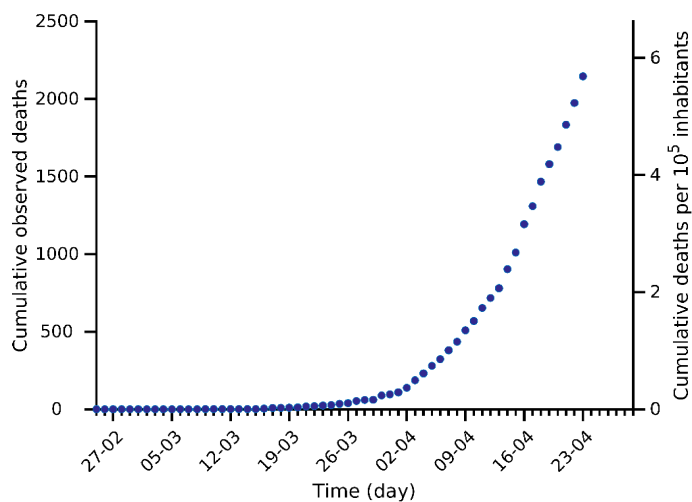
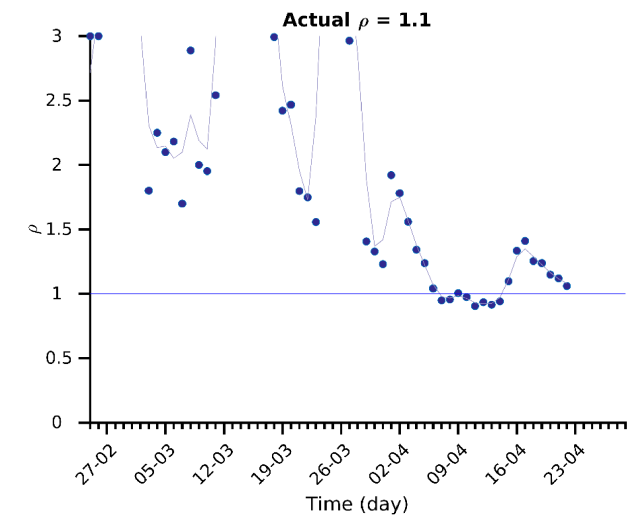
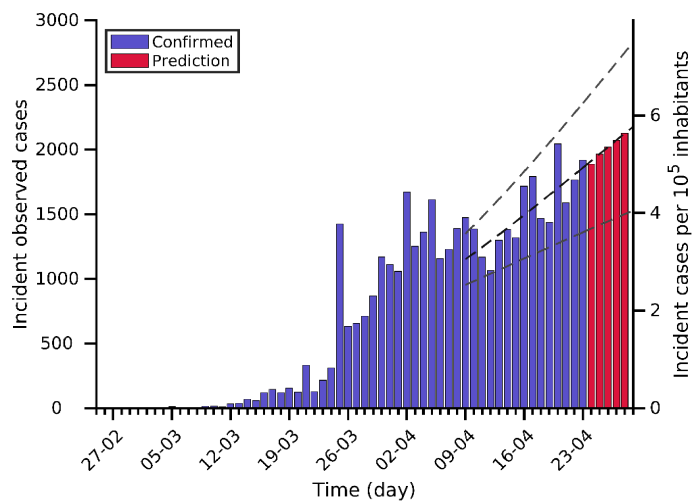
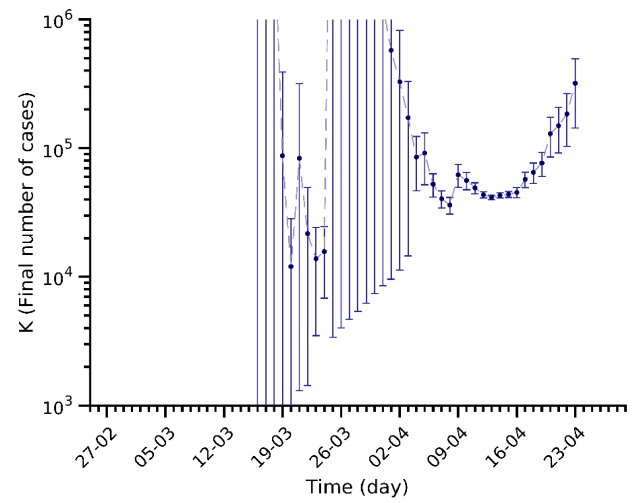
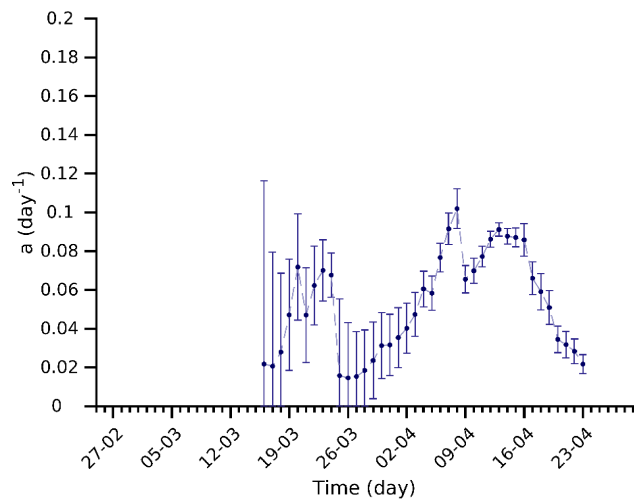
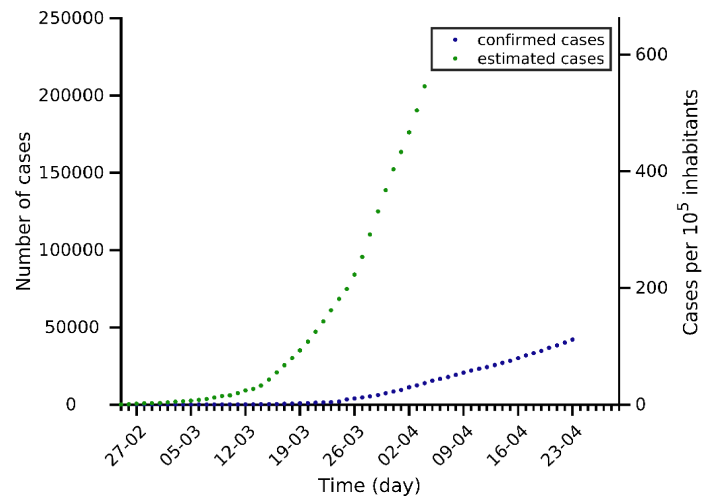
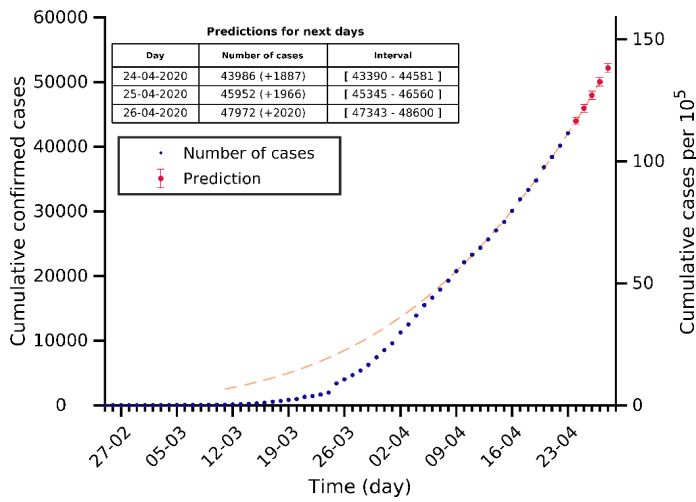
Russia 23-04-2020. Population: 145.9M. Current cumulated incidence: 43/10⁵

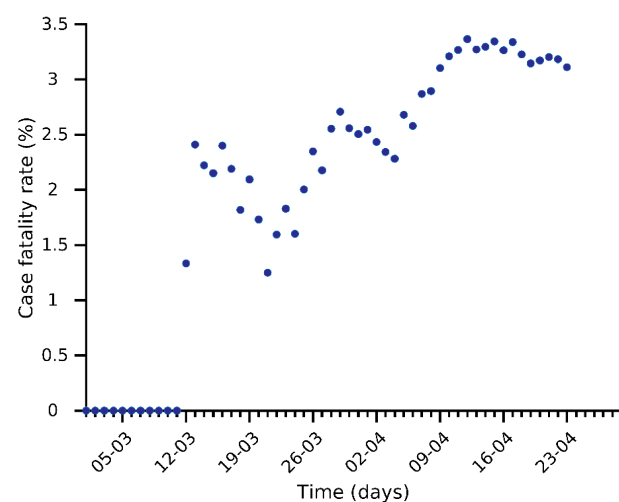
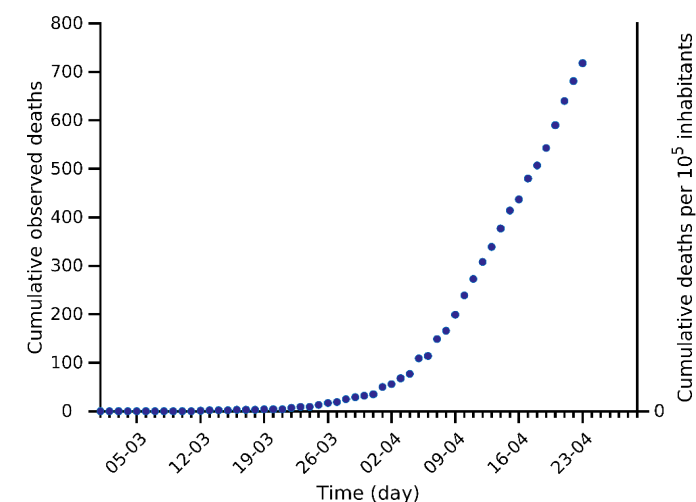
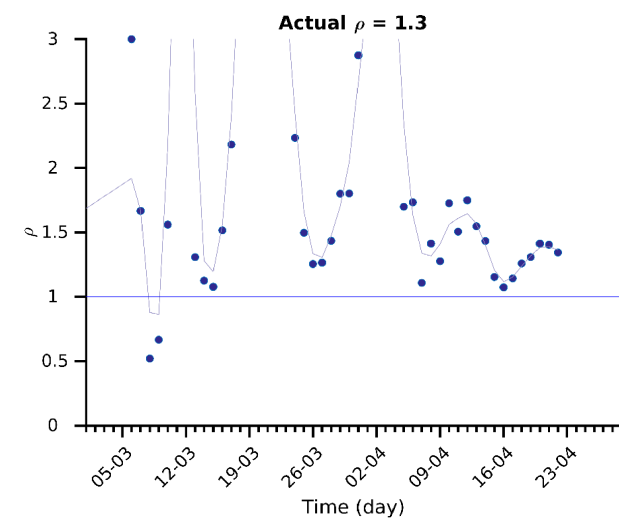
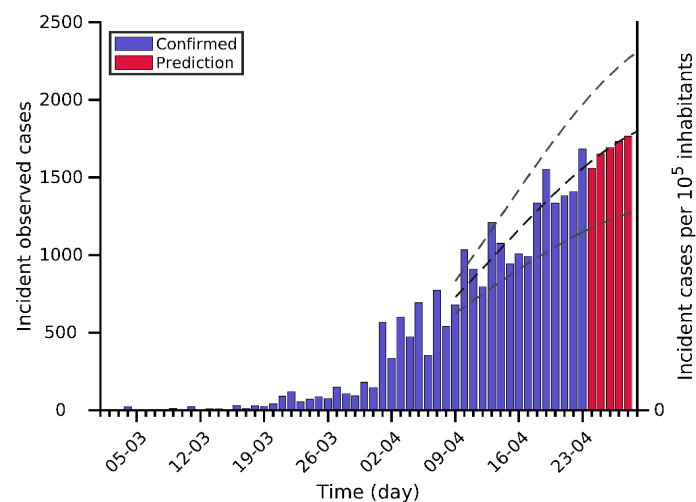
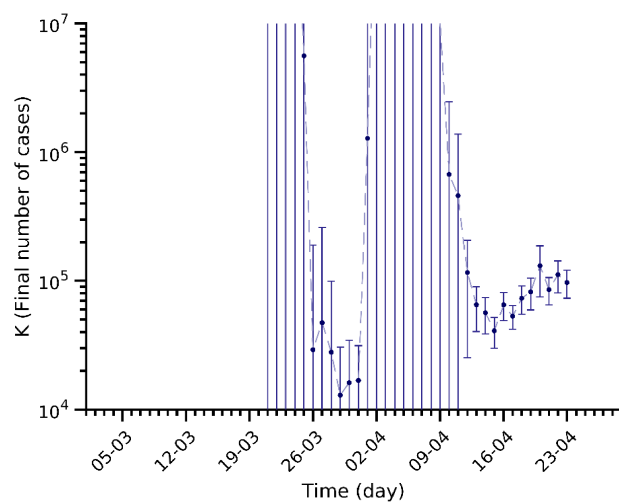
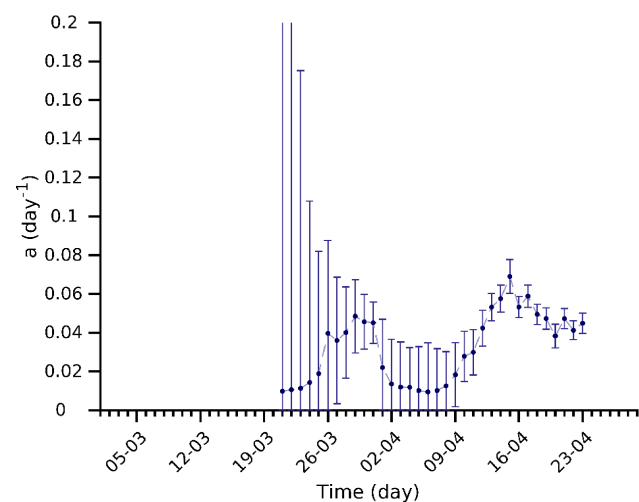
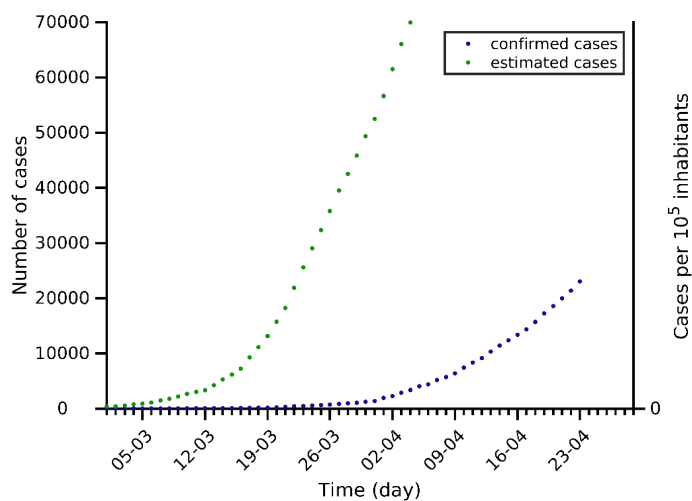
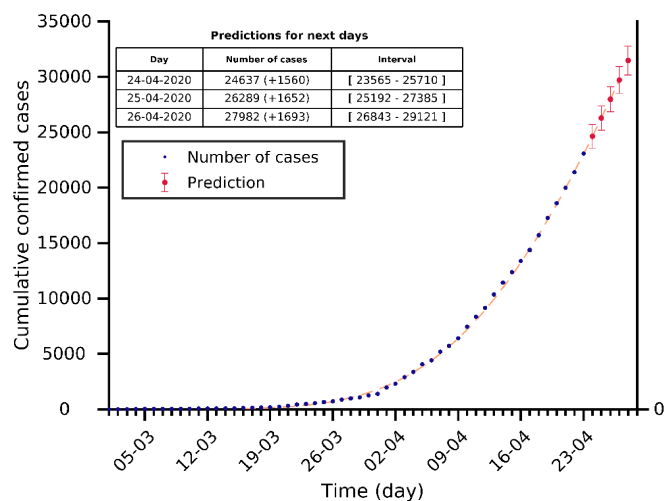


Brazil 23-04-2020. Population: 212.6M. Current cumulated incidence: 23/10⁵

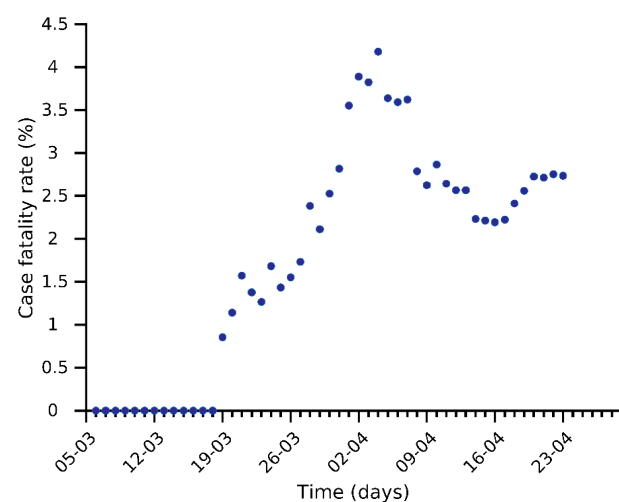
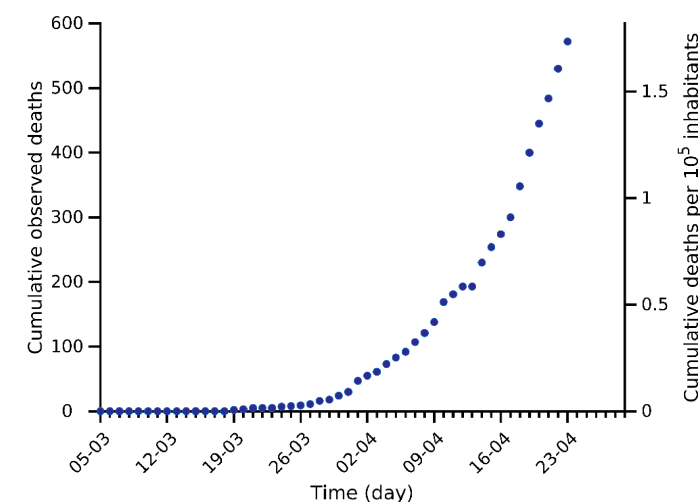
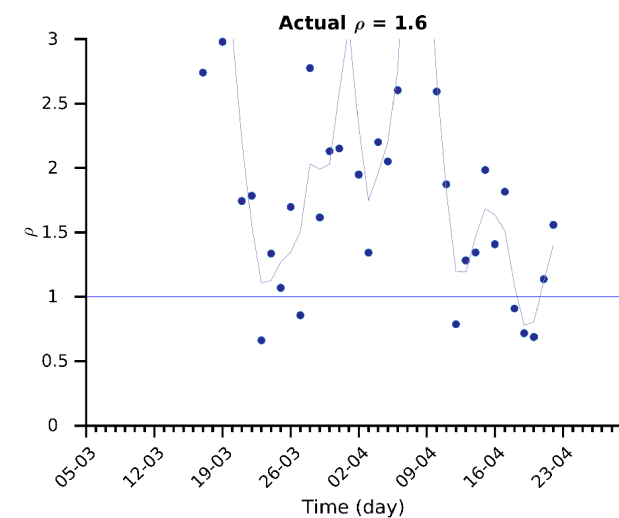
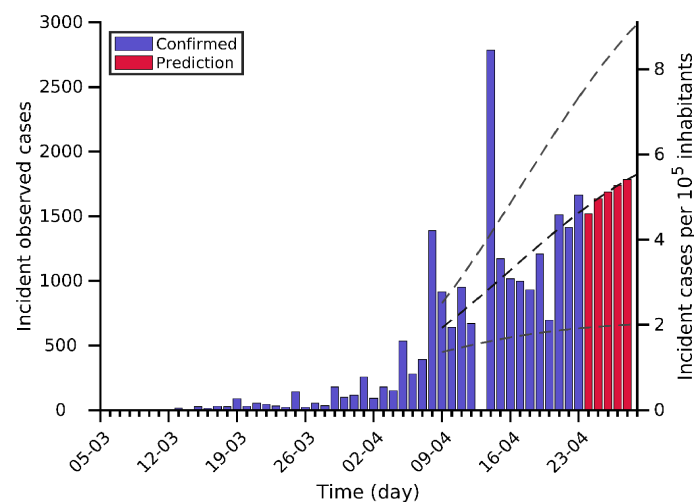
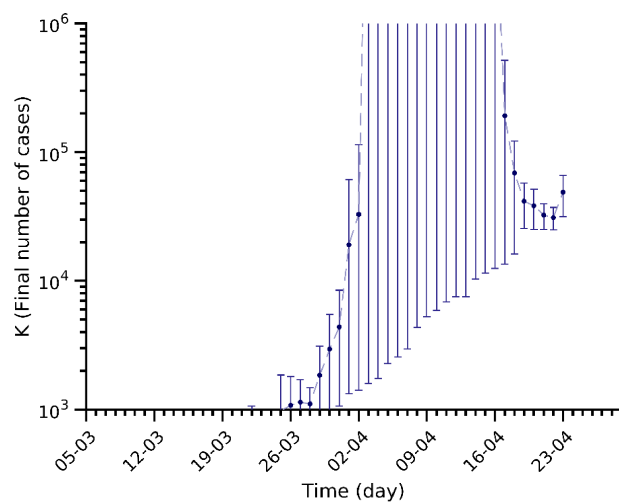
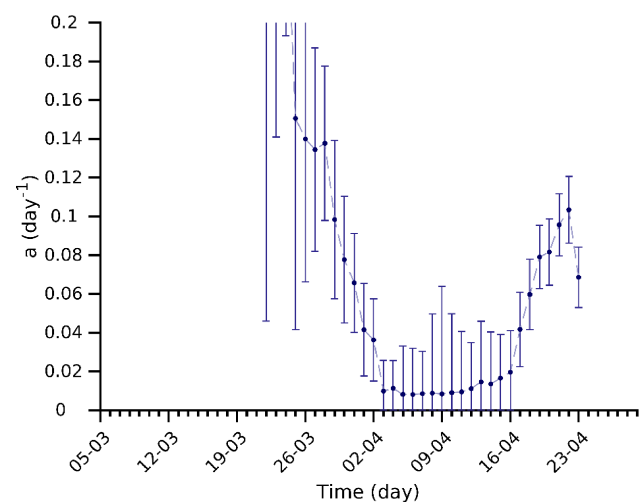
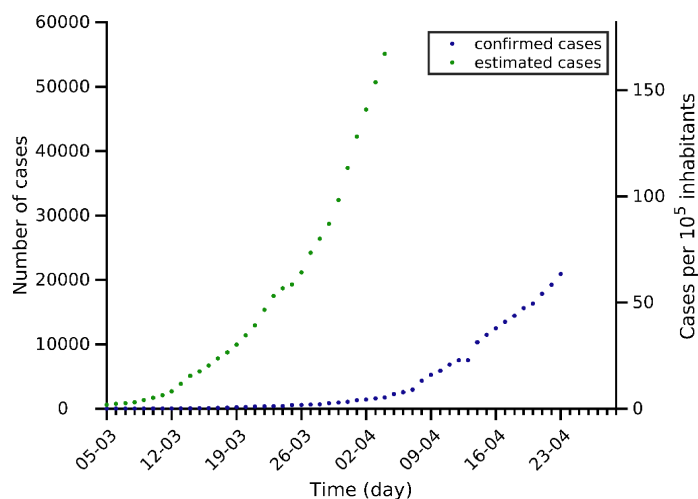
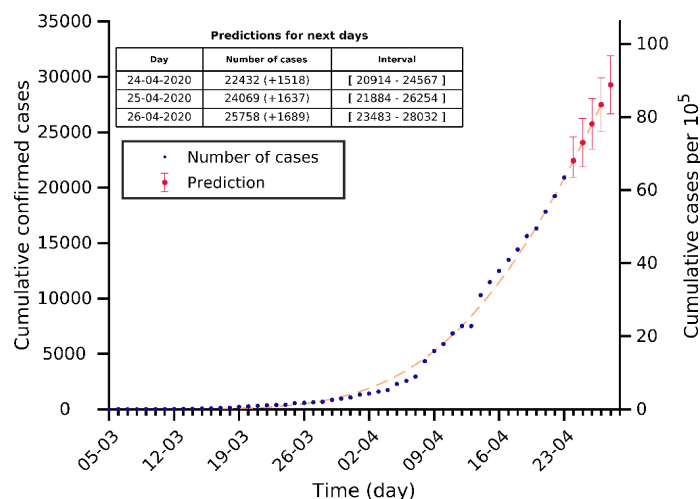


Canada 23-04-2020. Population: 37.7M. Current cumulated incidence: 112/10⁵

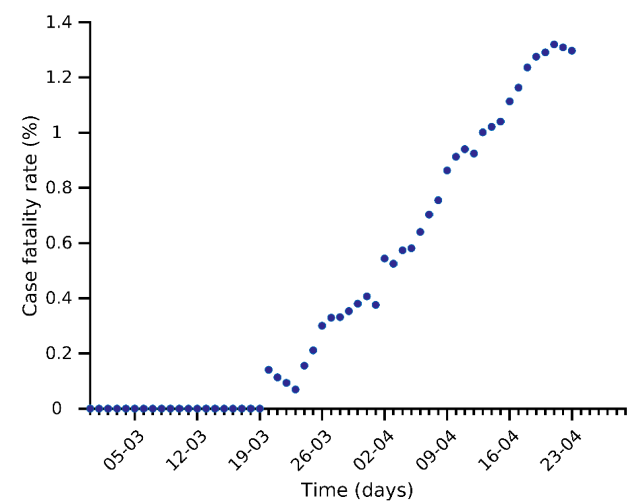
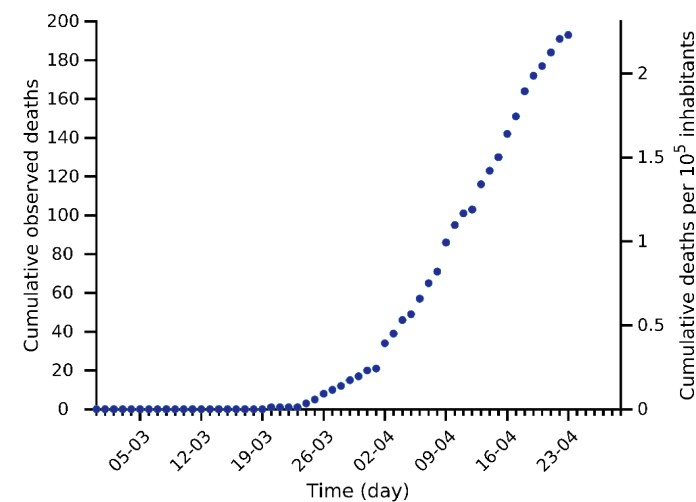
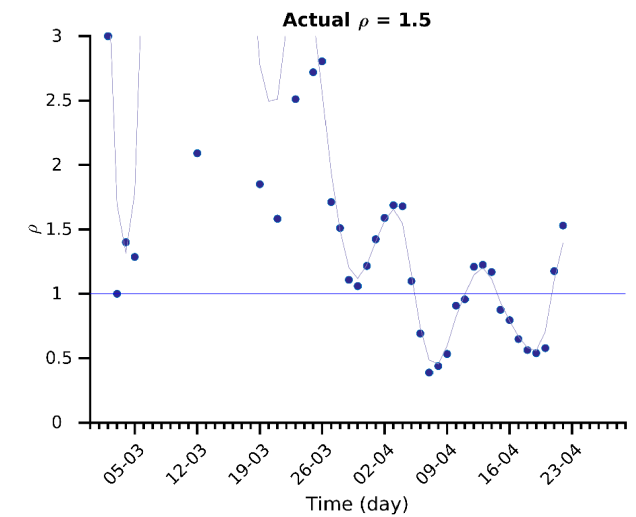
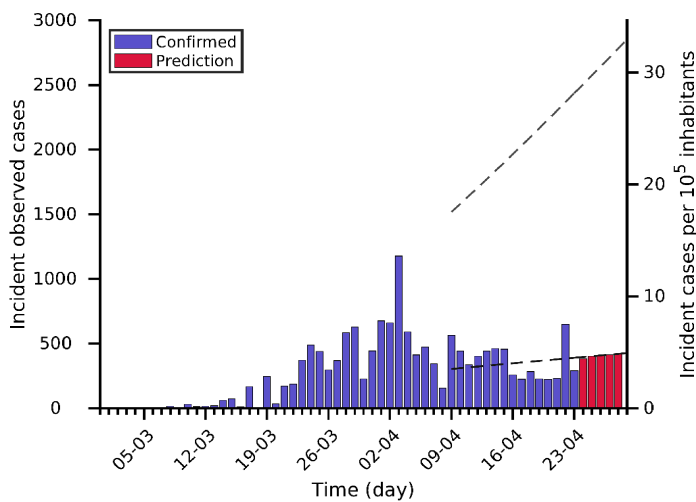
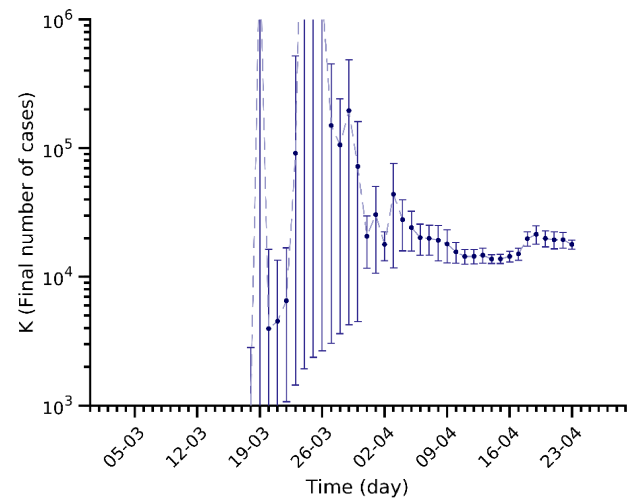
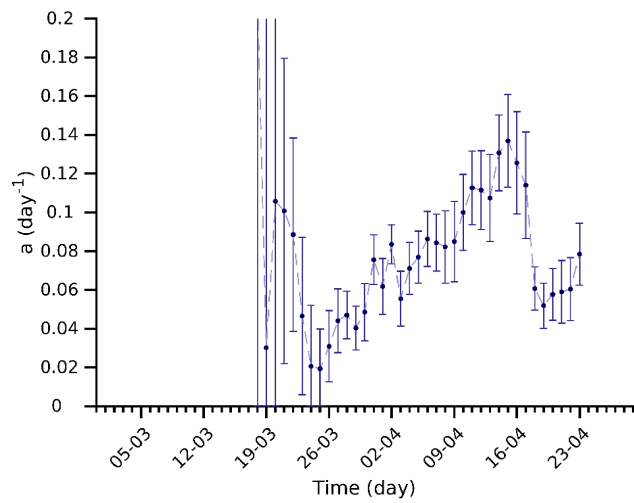
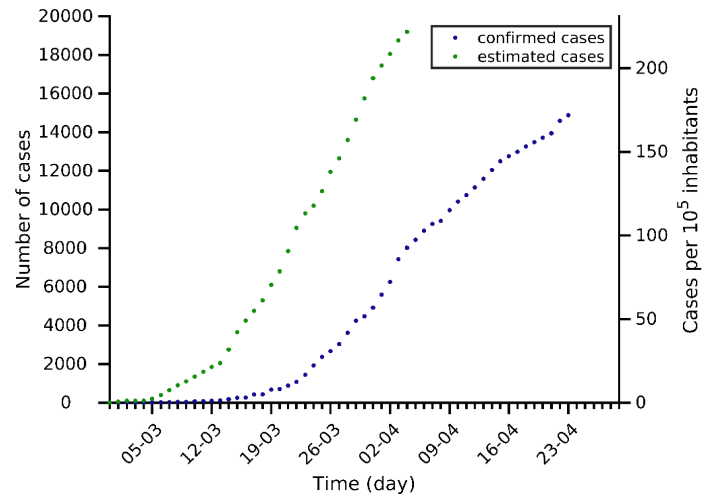
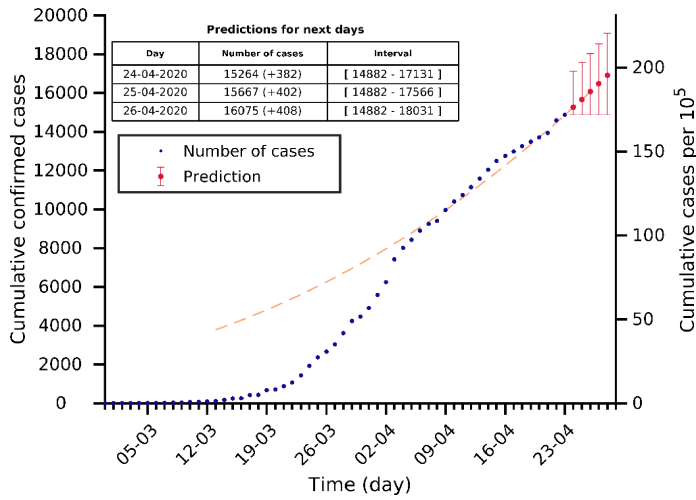




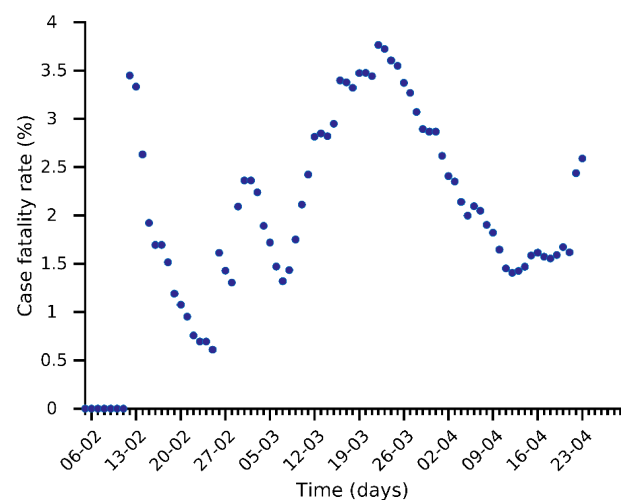
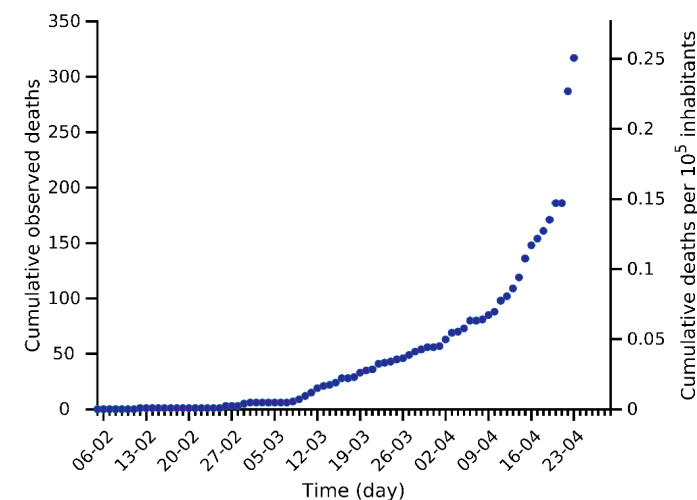
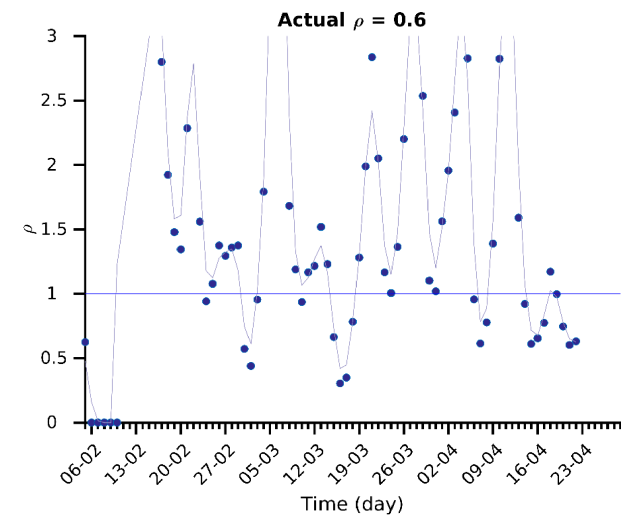
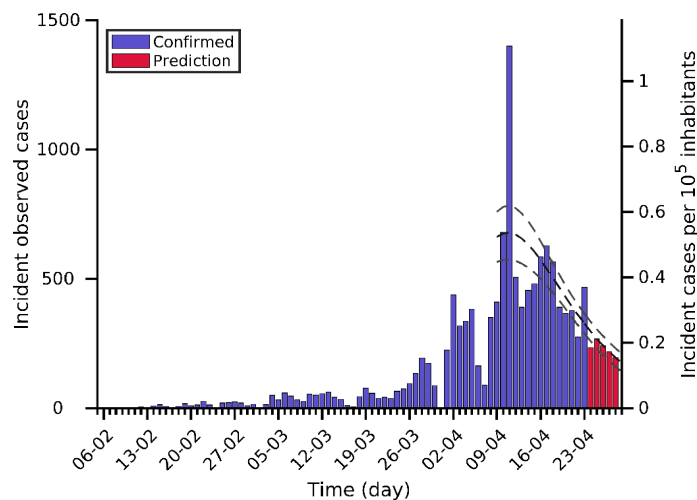
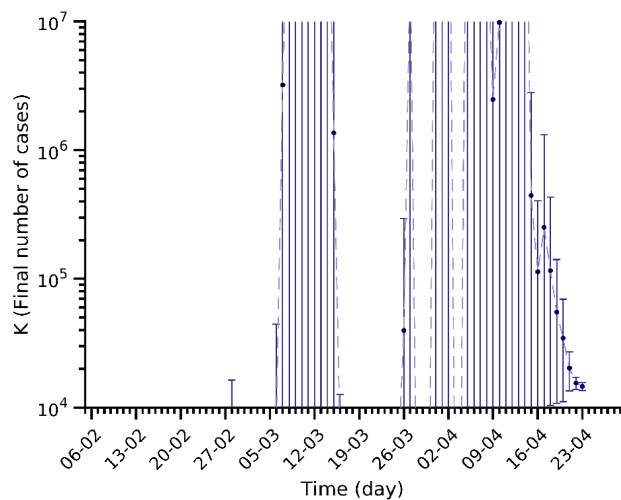
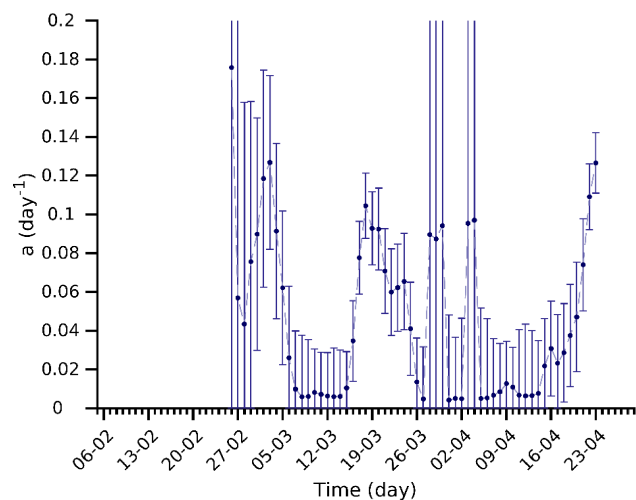
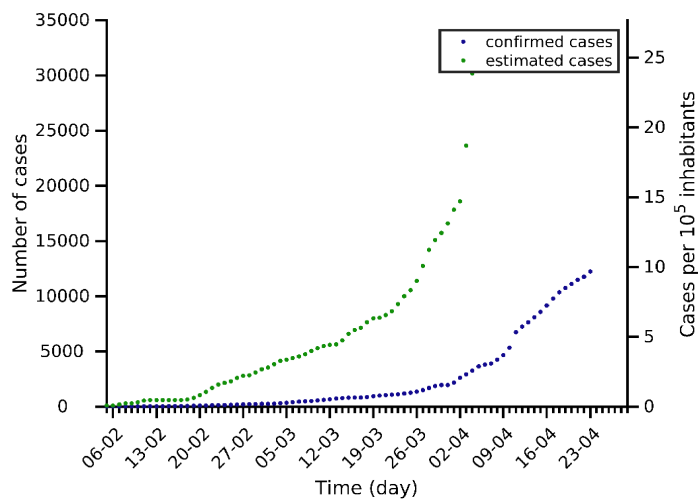
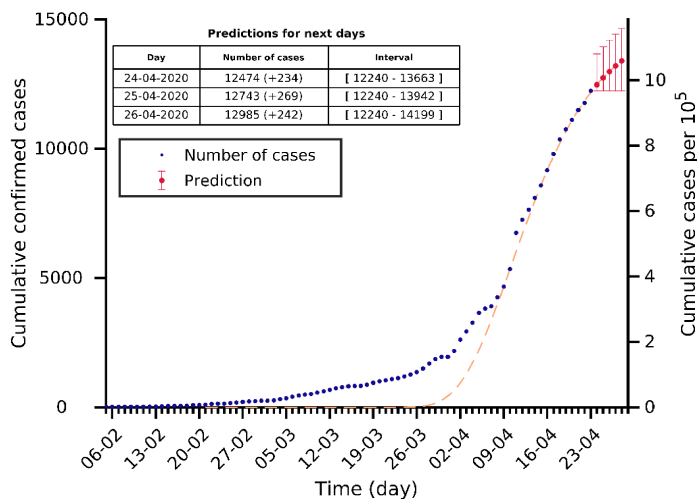
Peru 23-04-2020. Population: 33.0M. Current cumulated incidence: 63/10⁵



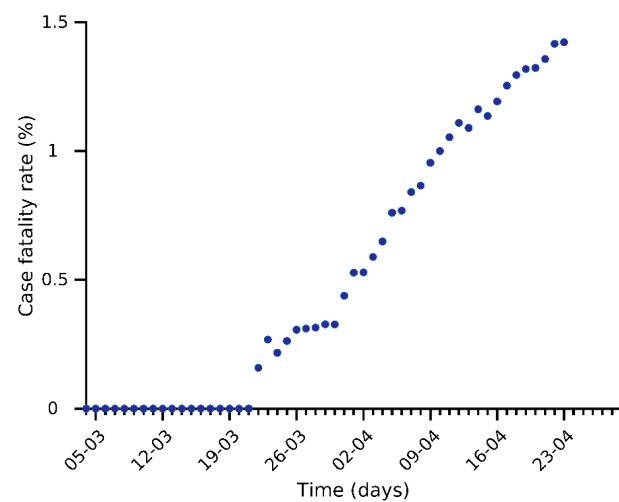
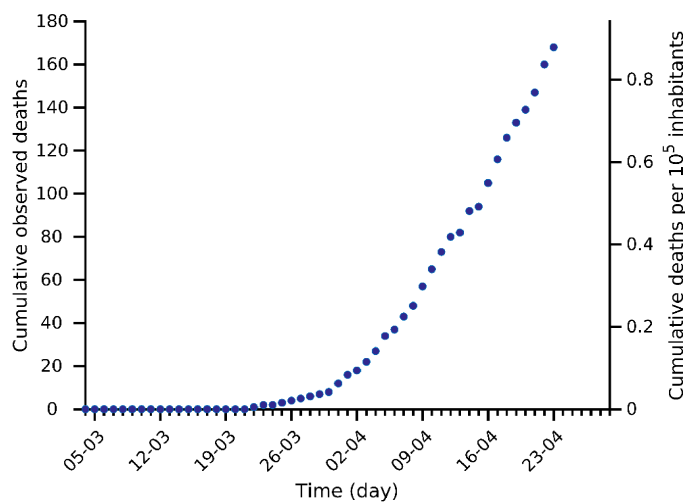
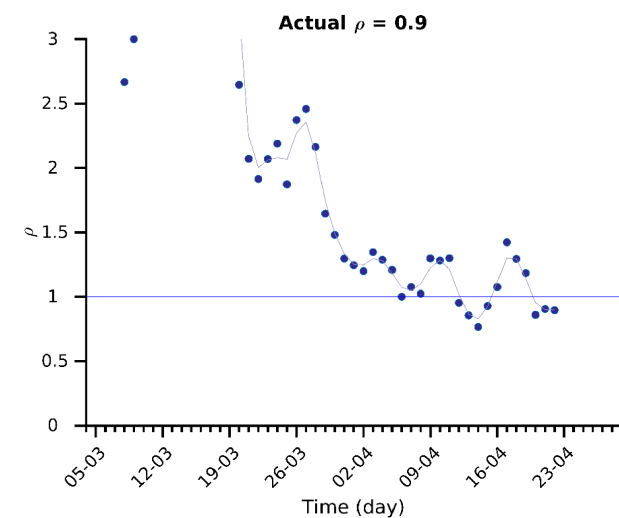
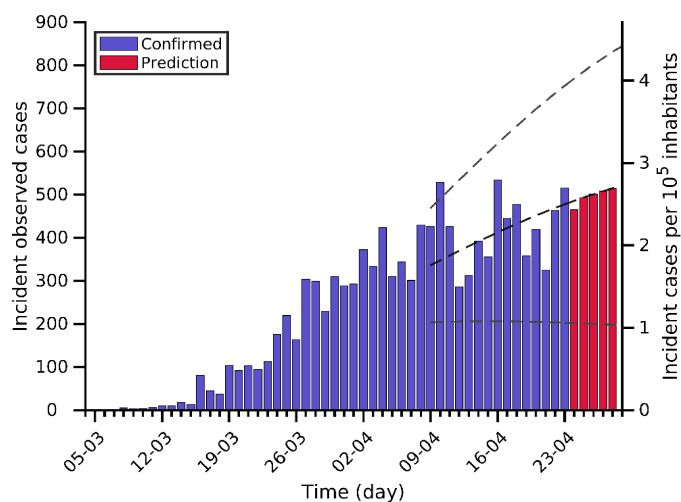
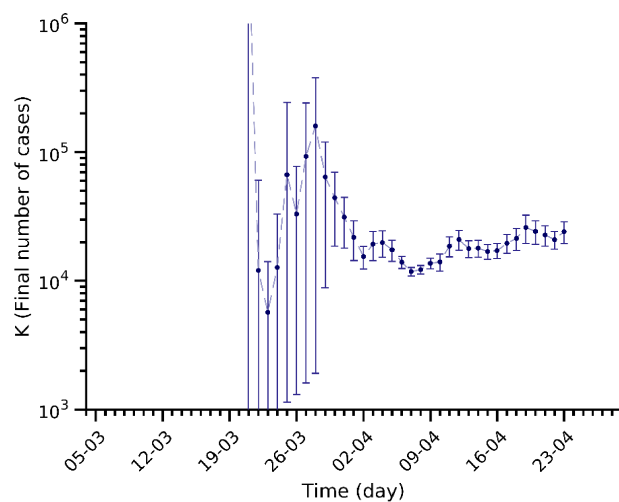
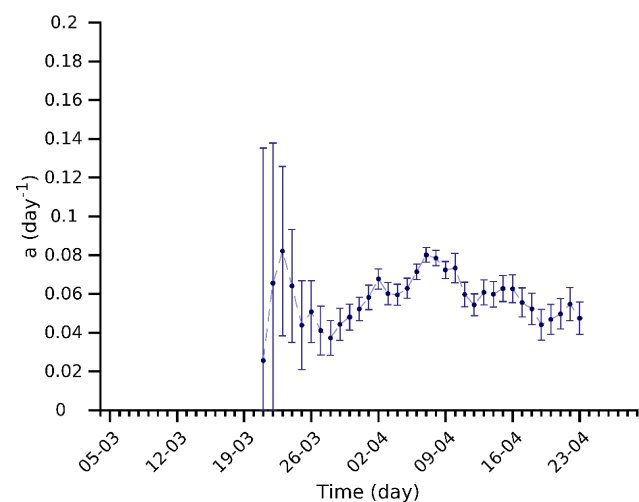
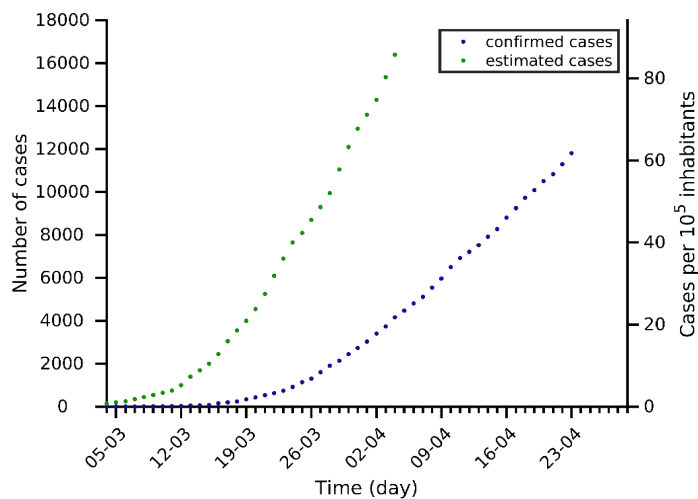
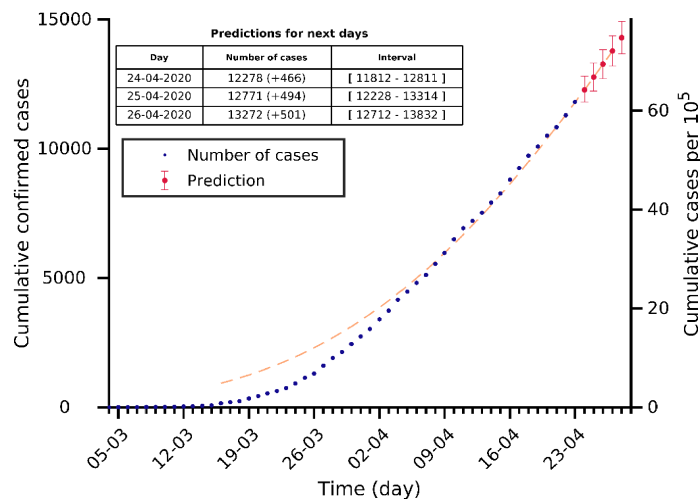
Israel 23-04-2020. Population: 8.7M. Current cumulated incidence: 172/10⁵



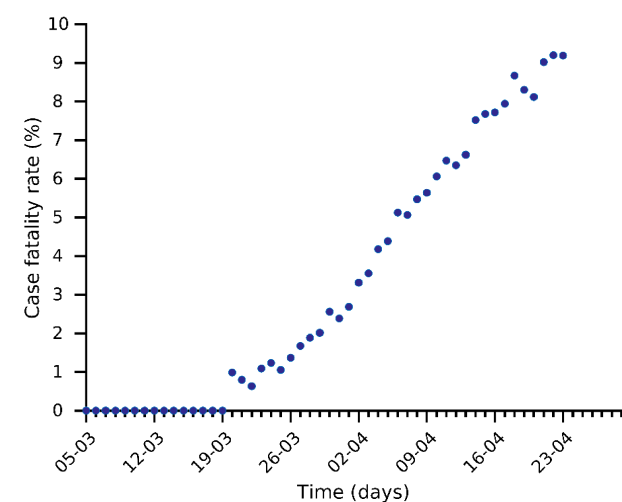
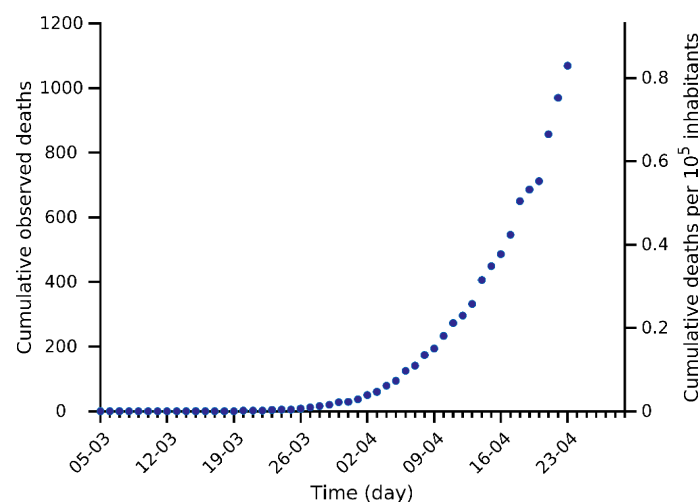
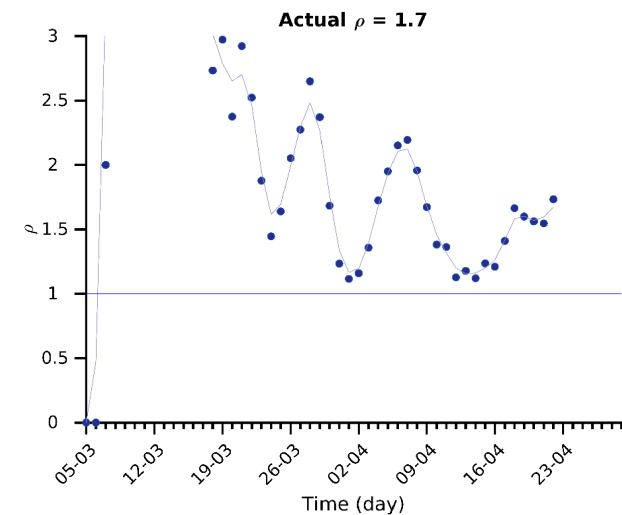
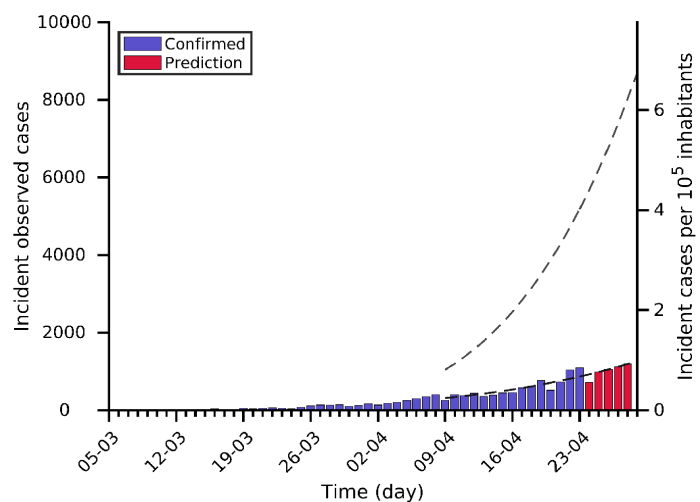
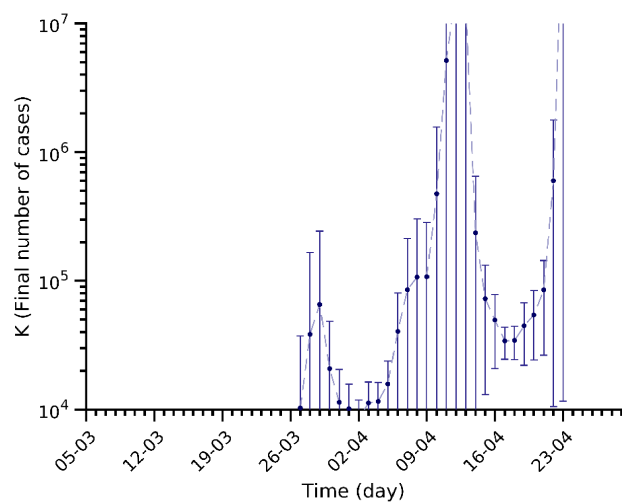
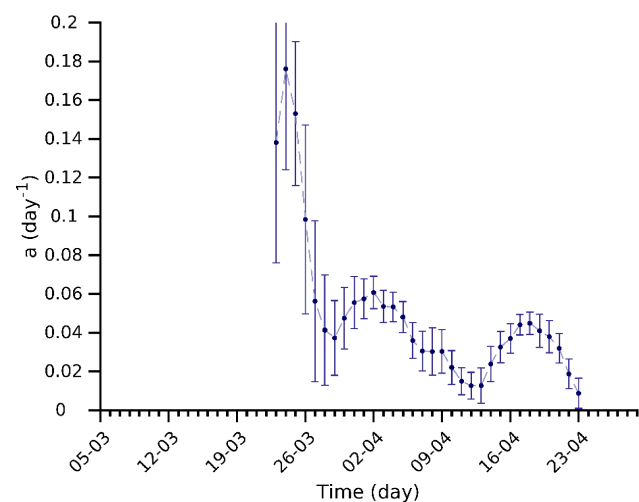
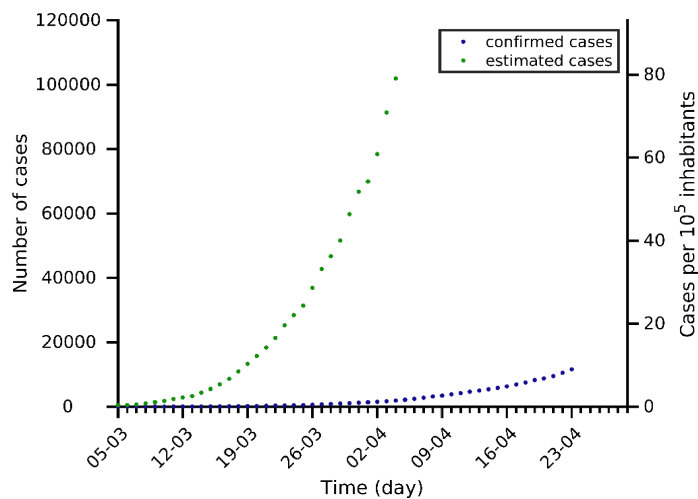
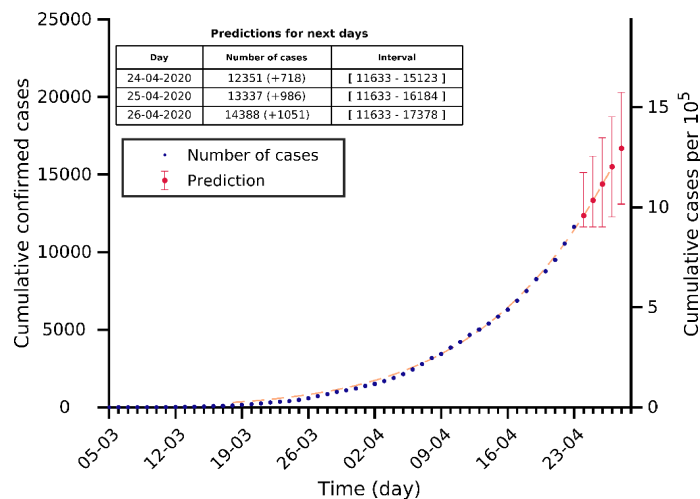
Japan 23-04-2020. Population: 126.5M. Current cumulated incidence: 10/10⁵



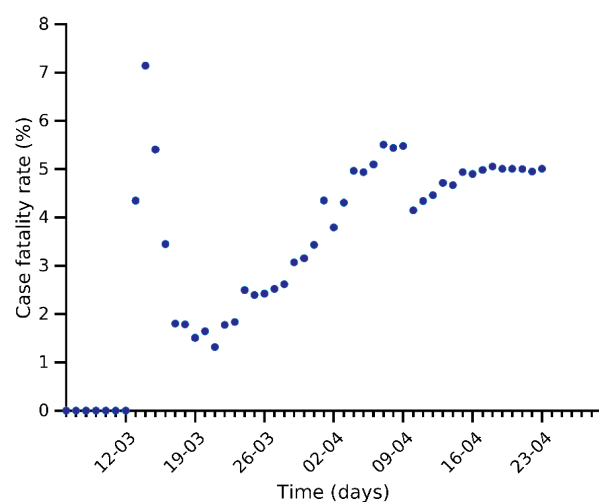
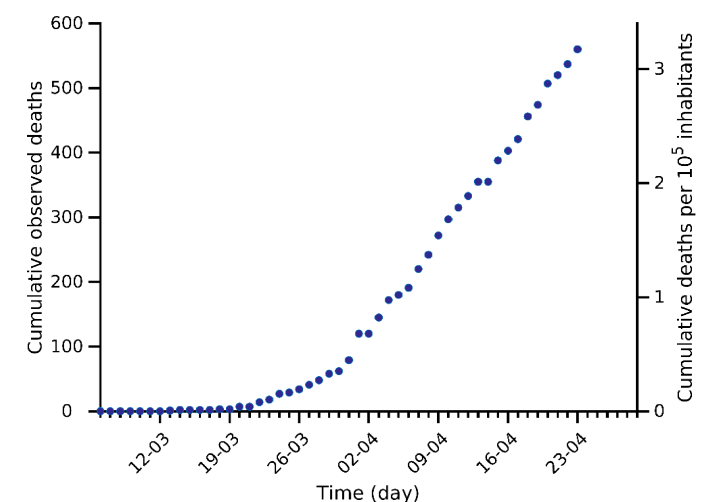
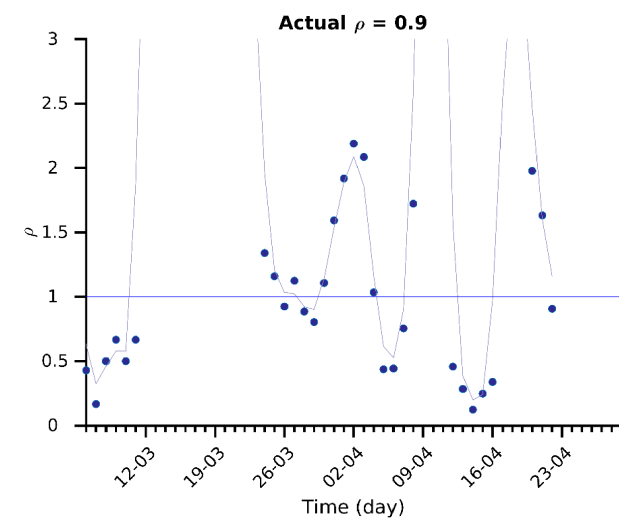
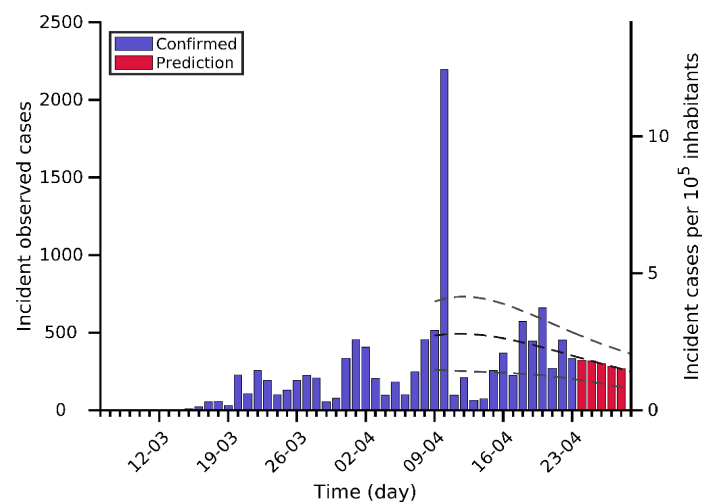
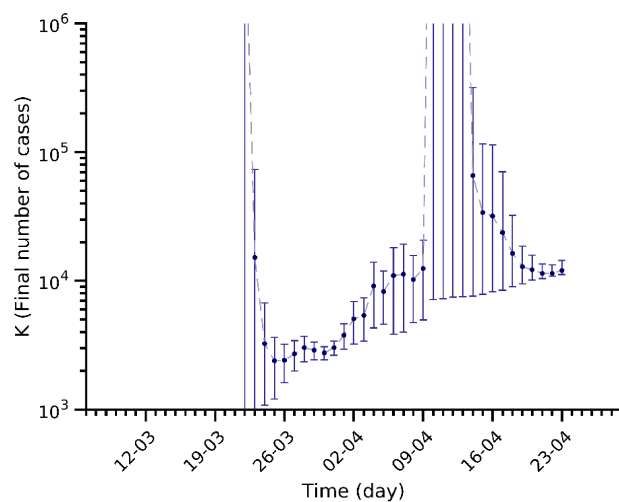
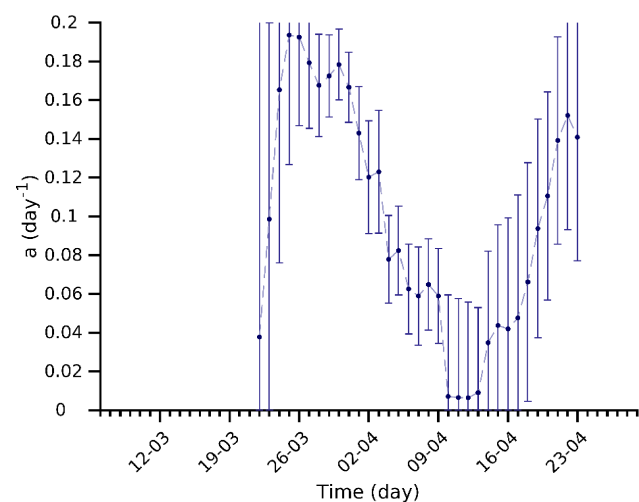
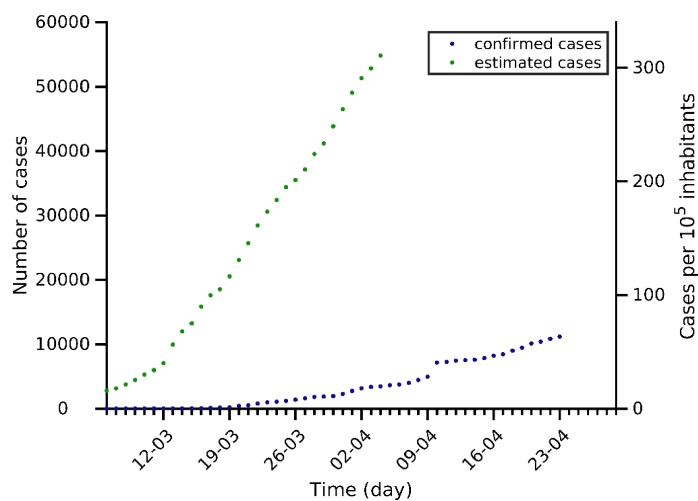
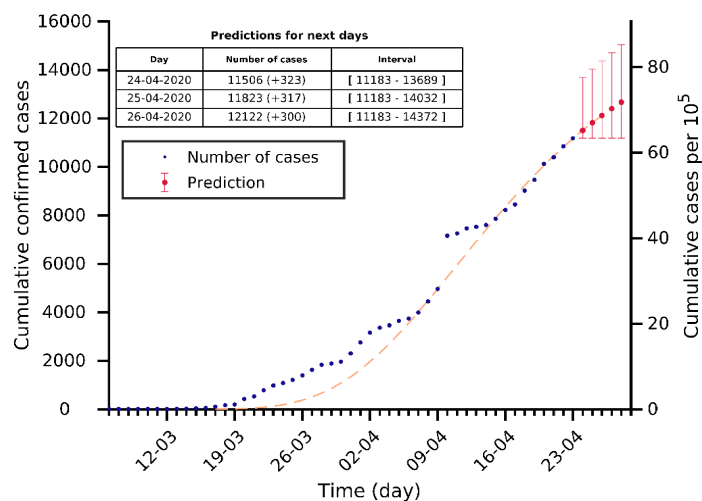
Chile 23-04-2020. Population: 19.1M. Current cumulated incidence: 62/10⁵



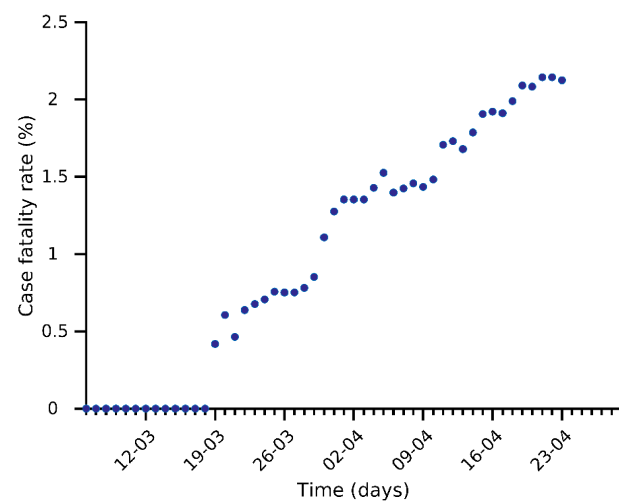
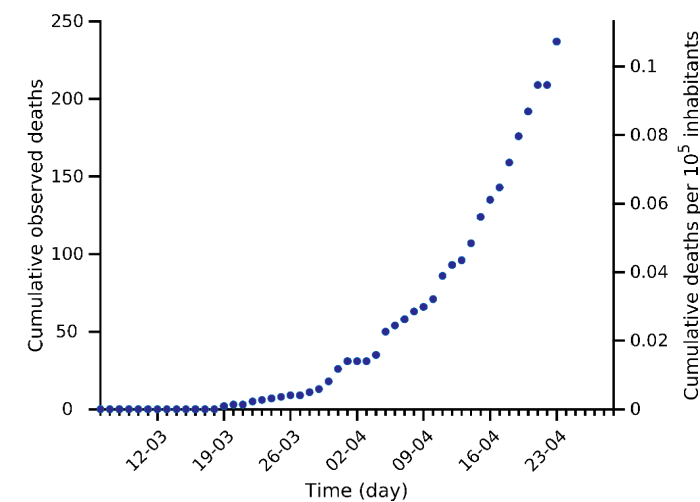
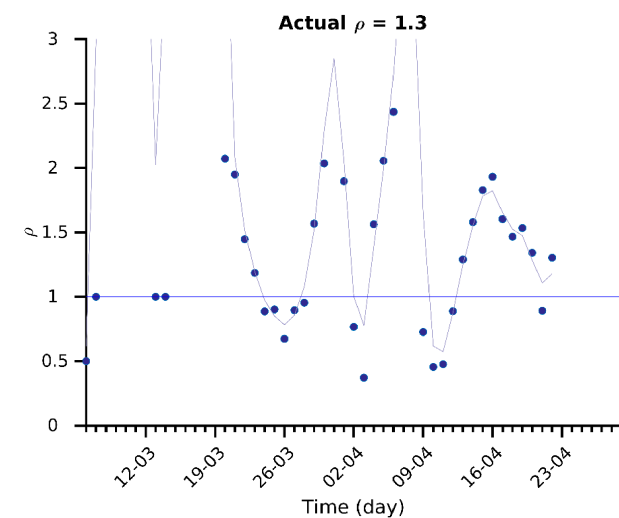
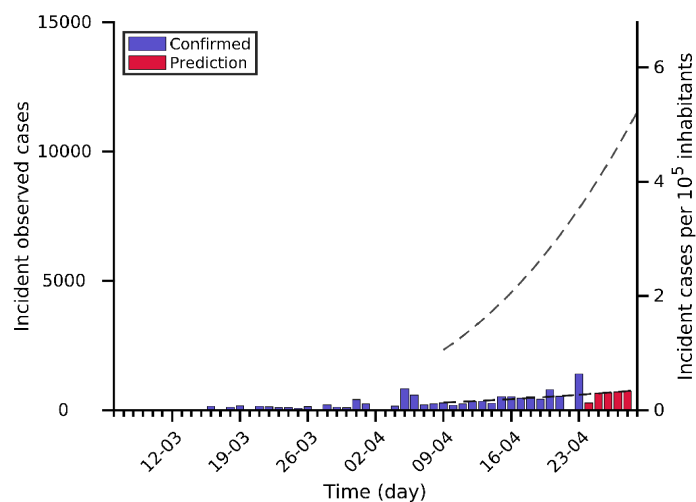
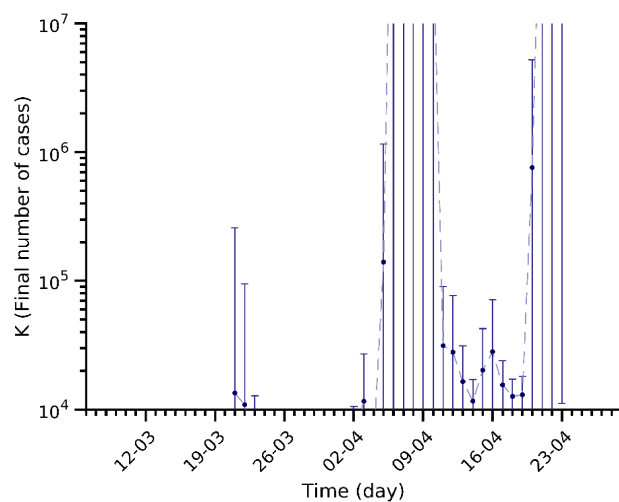
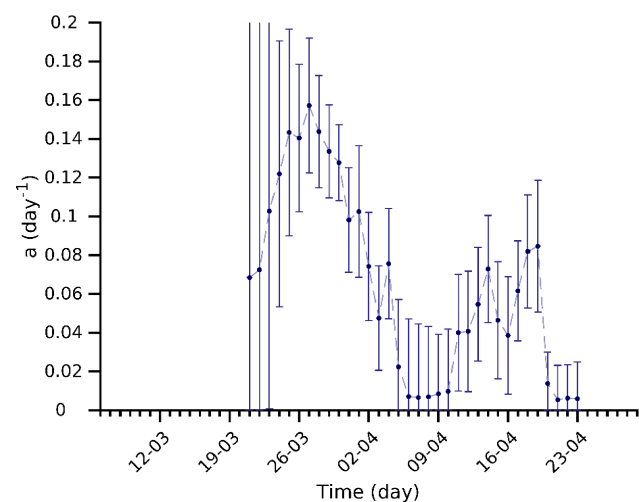
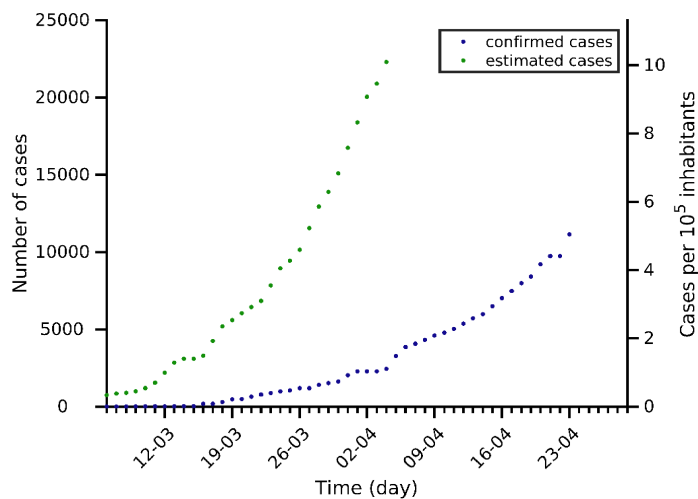
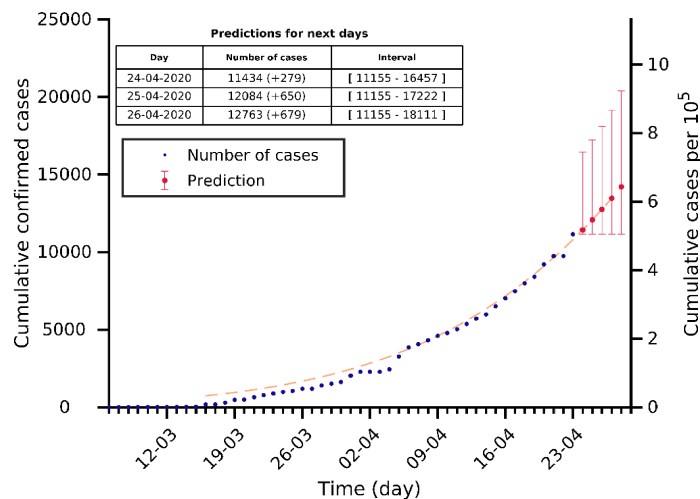
Mexico 23-04-2020. Population: 128.9M. Current cumulated incidence: 9/10⁵



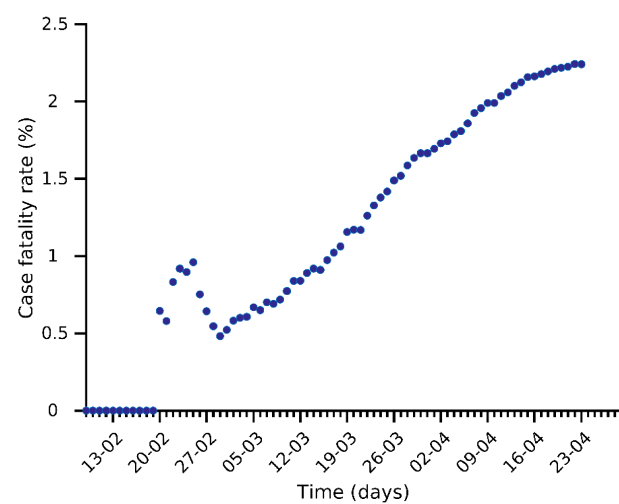
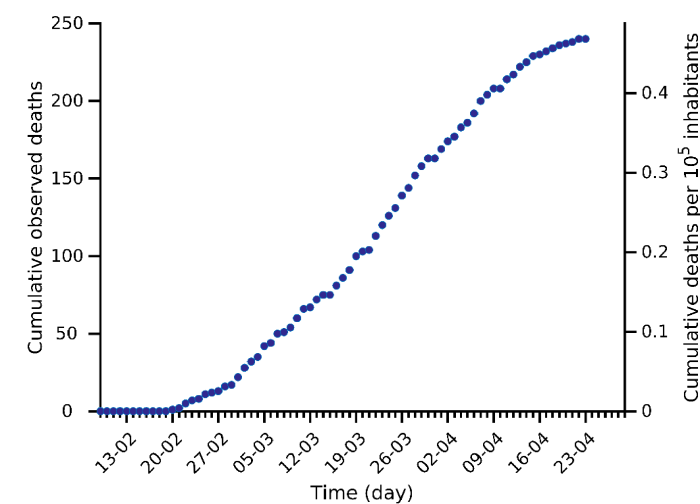
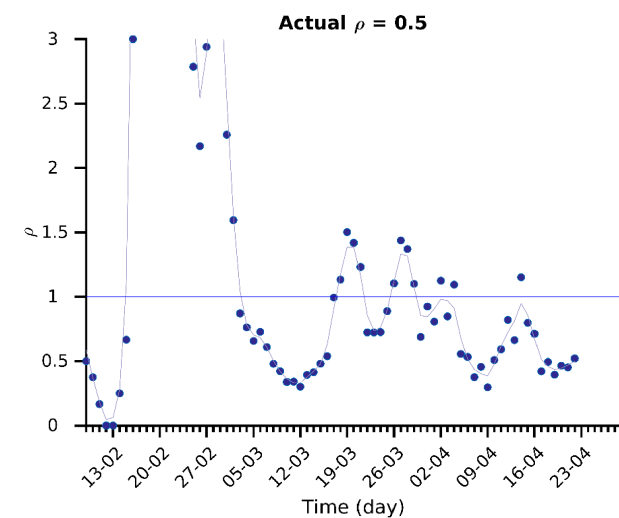
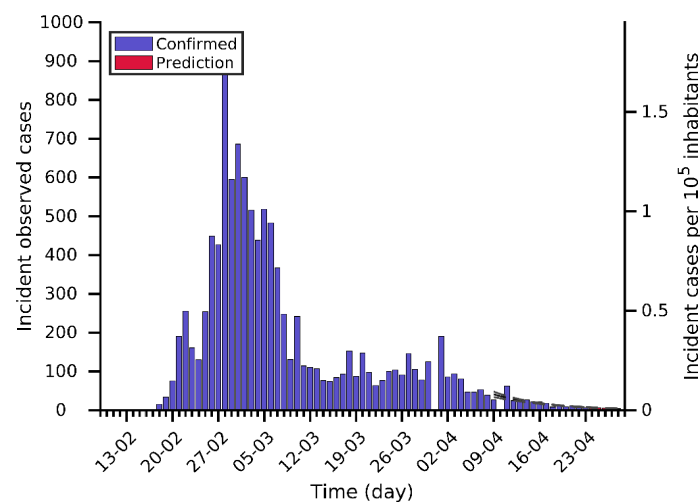
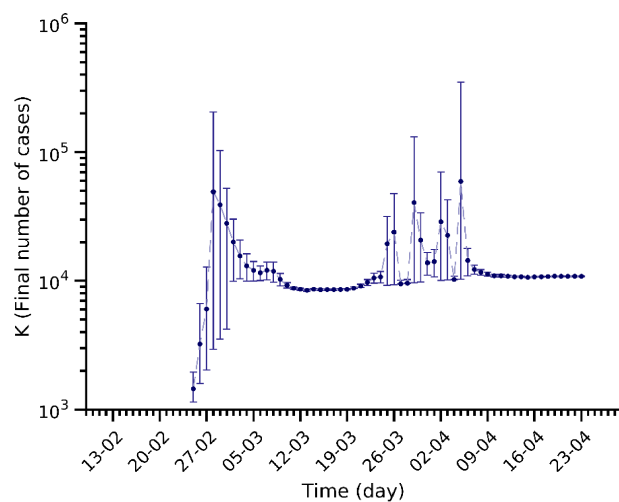
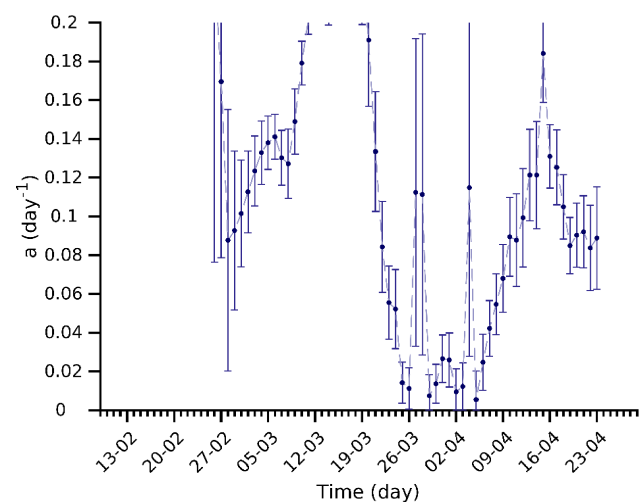
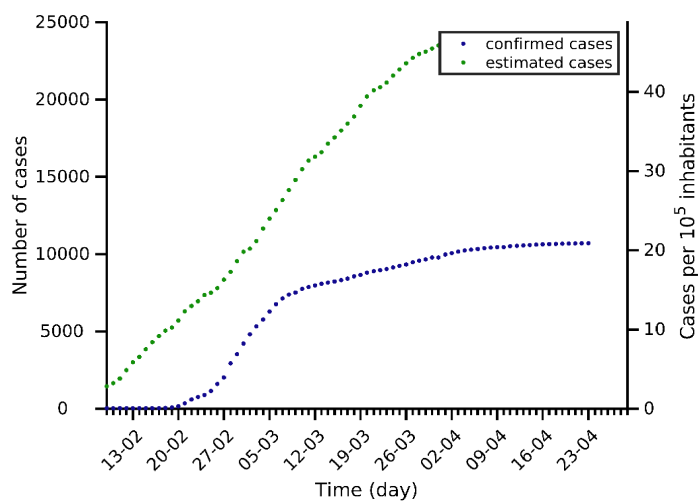
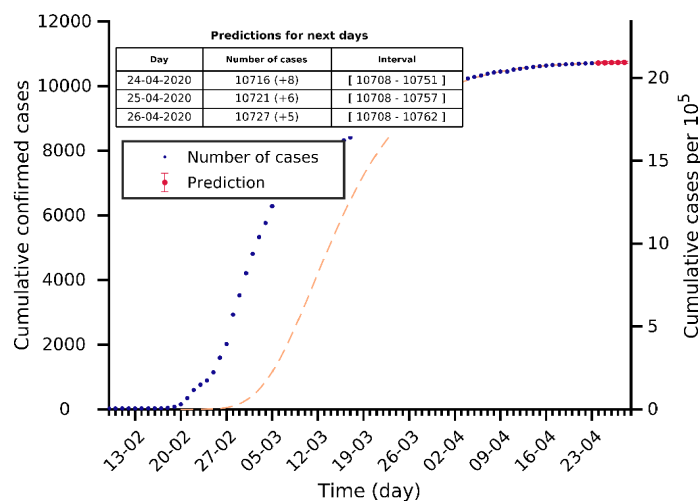
Ecuador 23-04-2020. Population: 17.6M. Current cumulated incidence: 63/10⁵



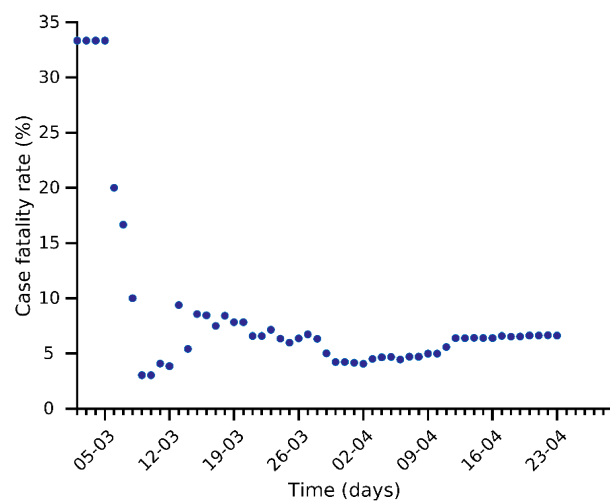
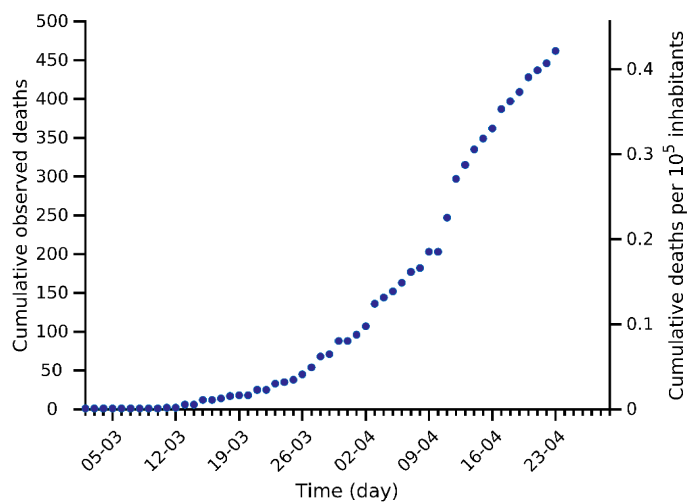
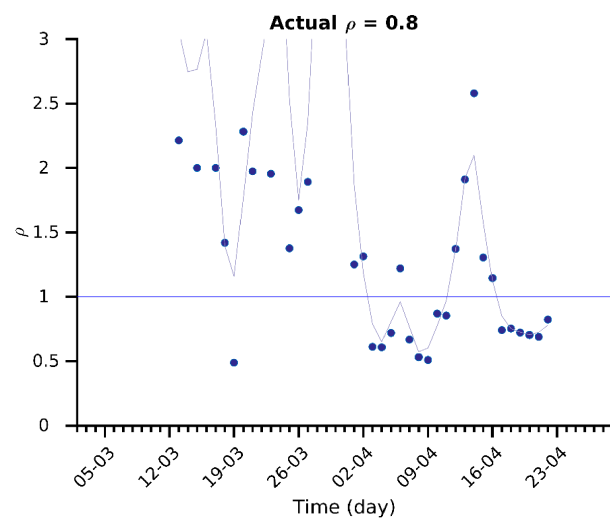
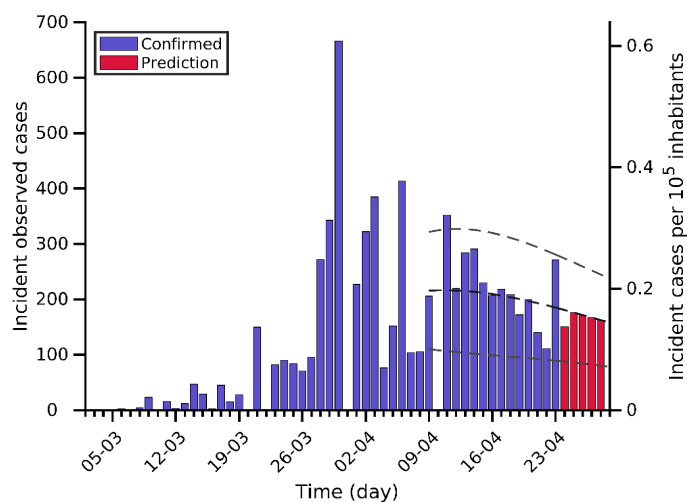
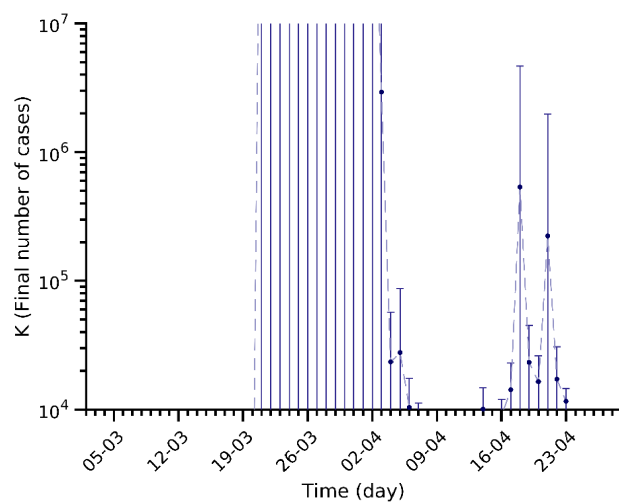
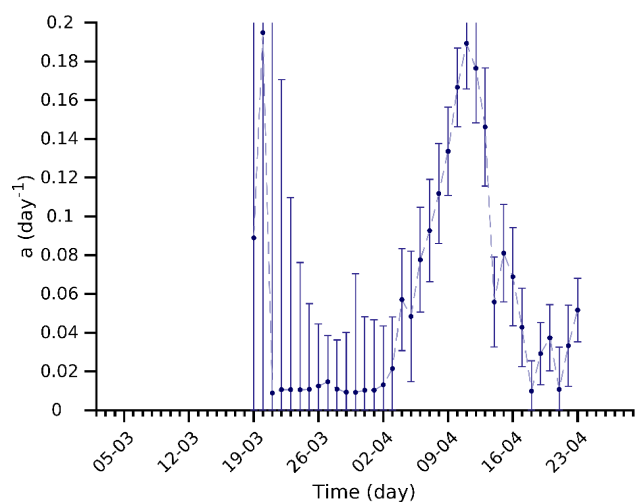
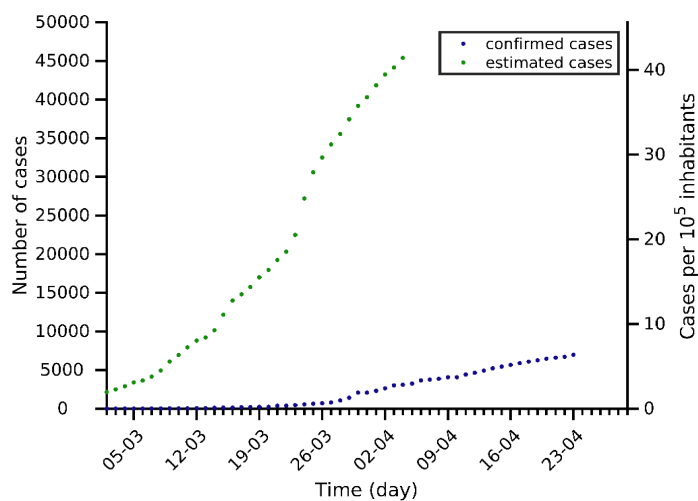
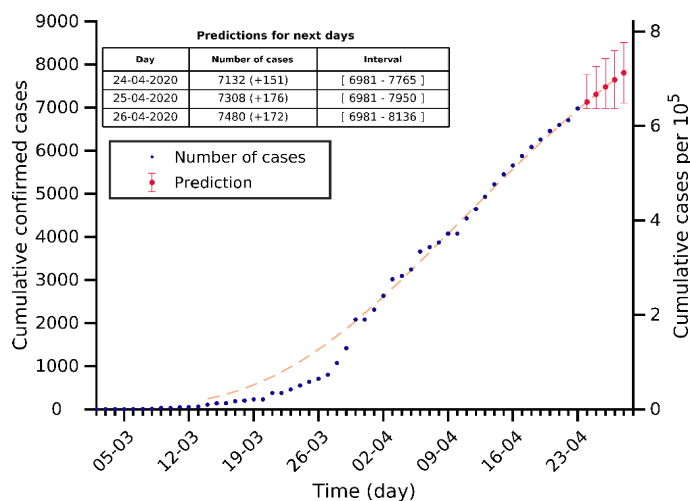
Pakistan 23-04-2020. Population: 220.9M. Current cumulated incidence: 5/10⁵



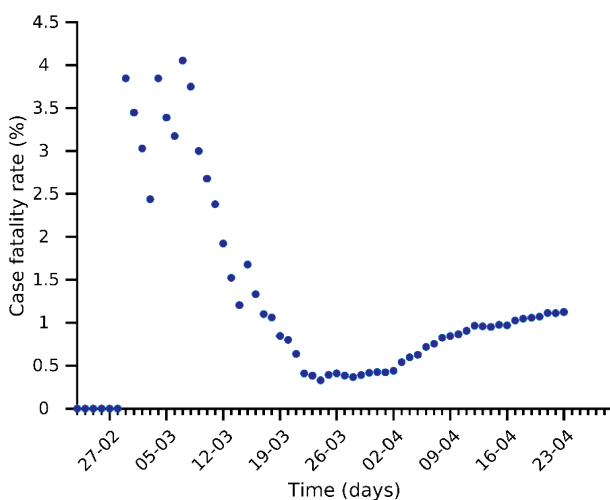
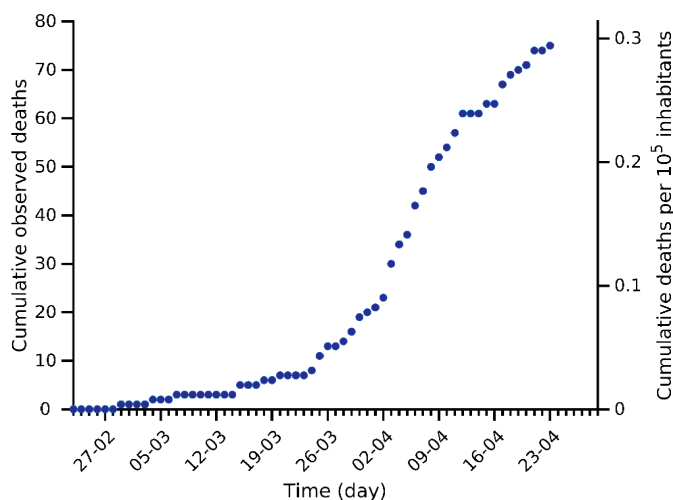
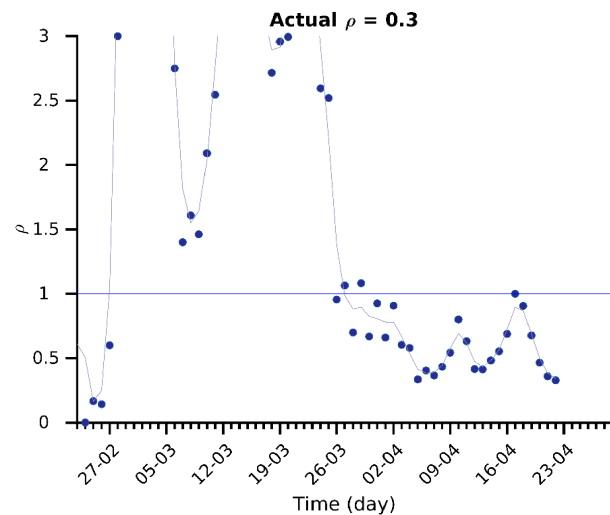
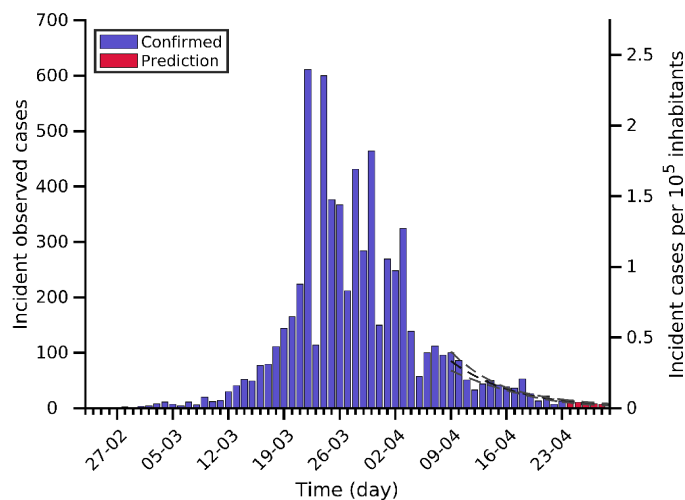
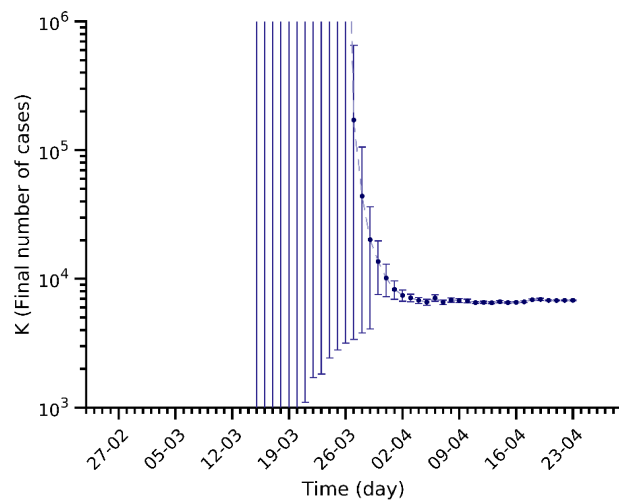
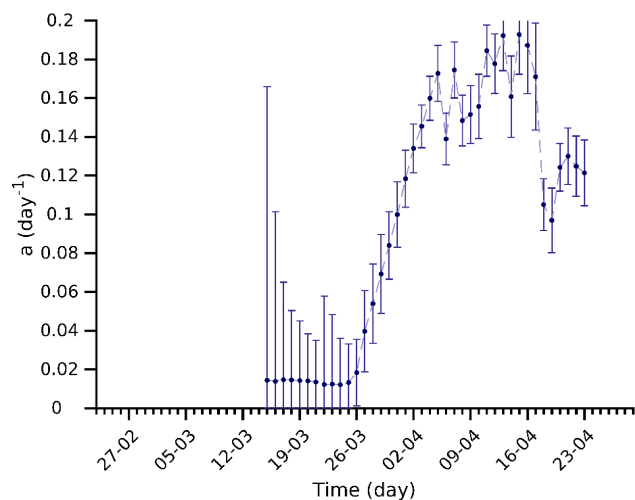
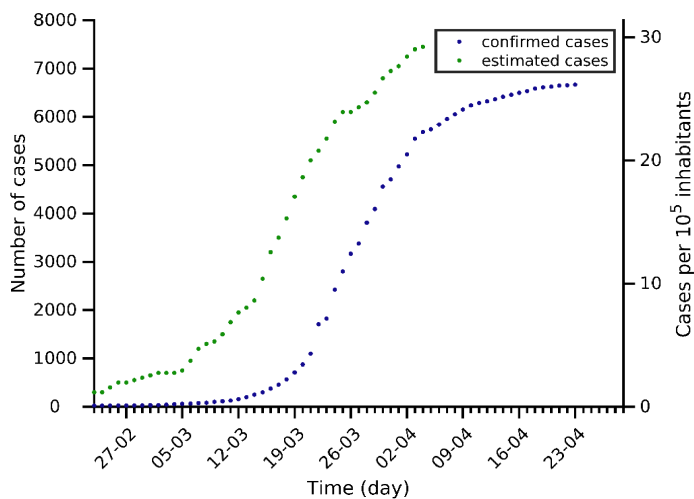
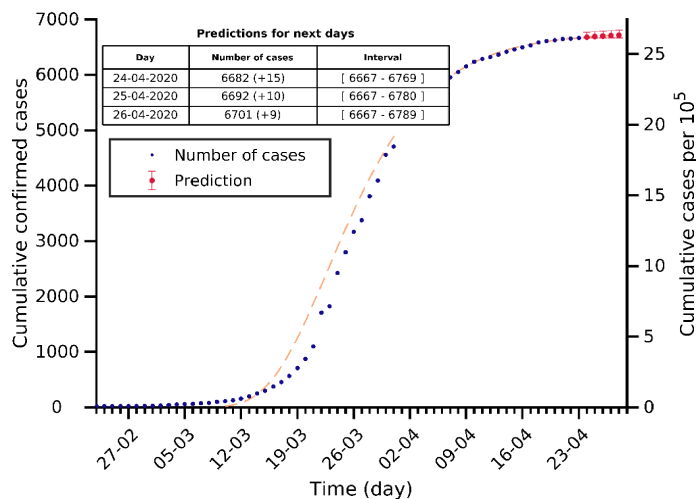
South Korea 23-04-2020. Population: 51.3M. Current cumulated incidence: 21/10⁵



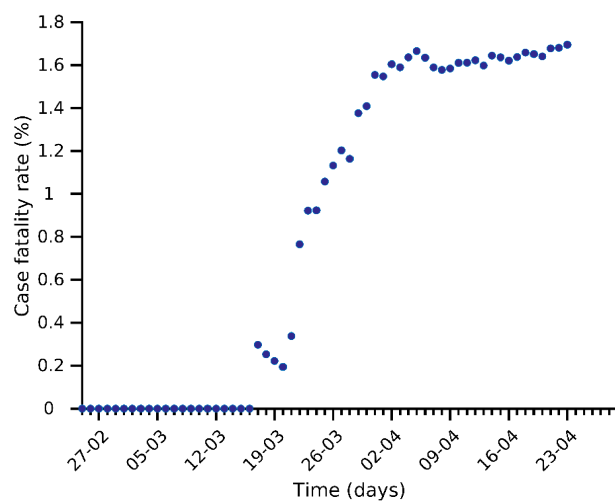
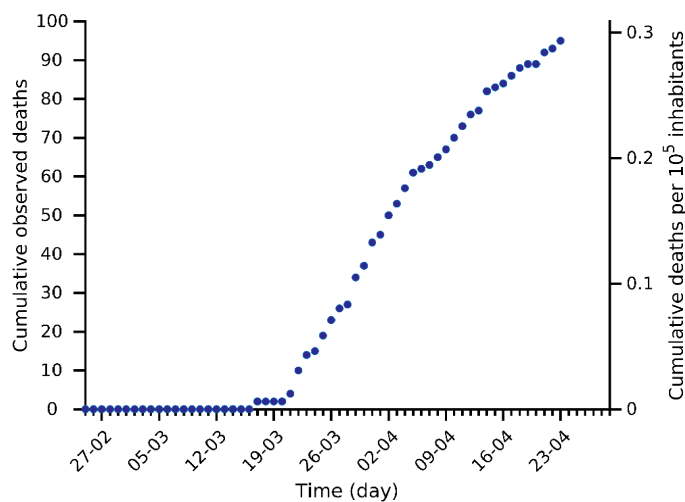
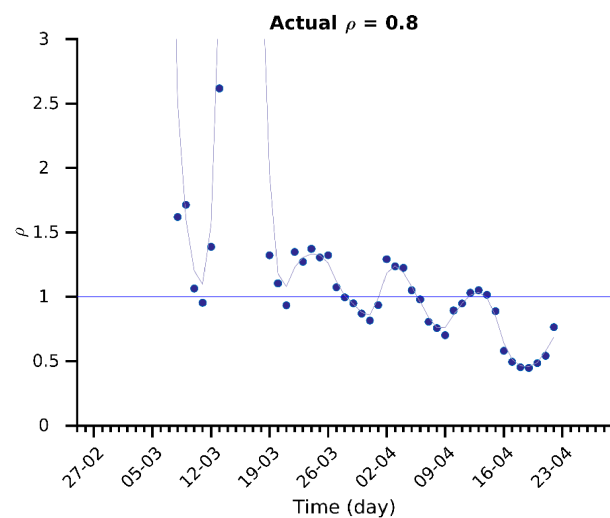
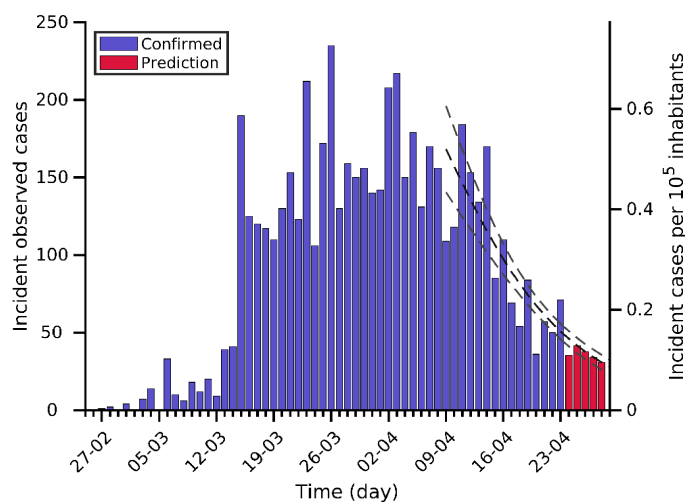
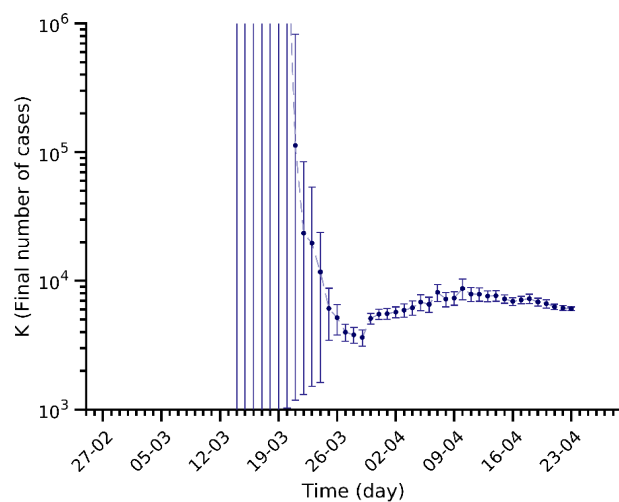
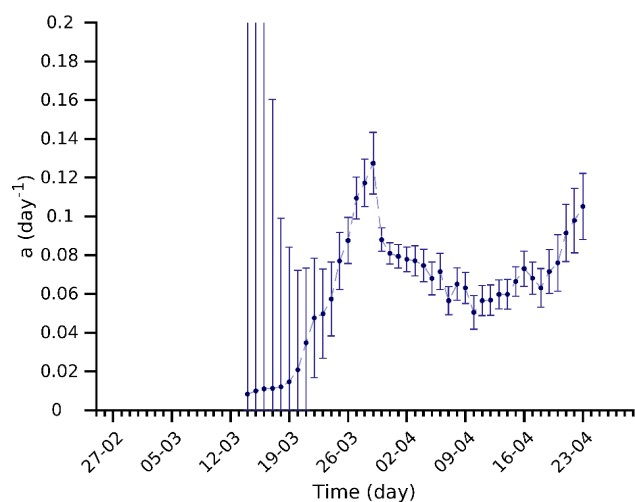
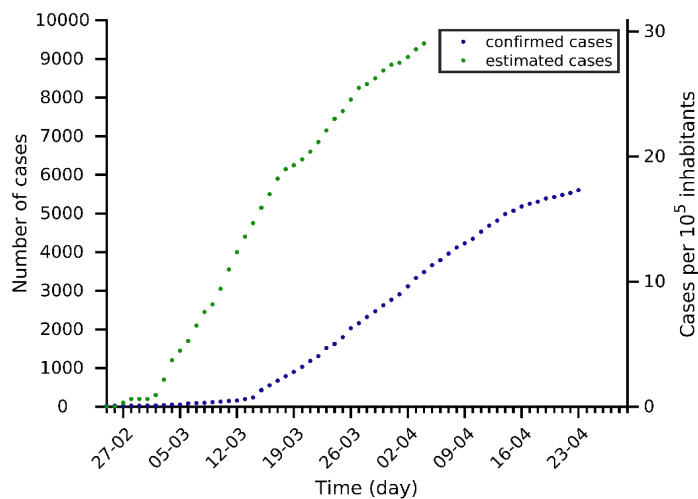
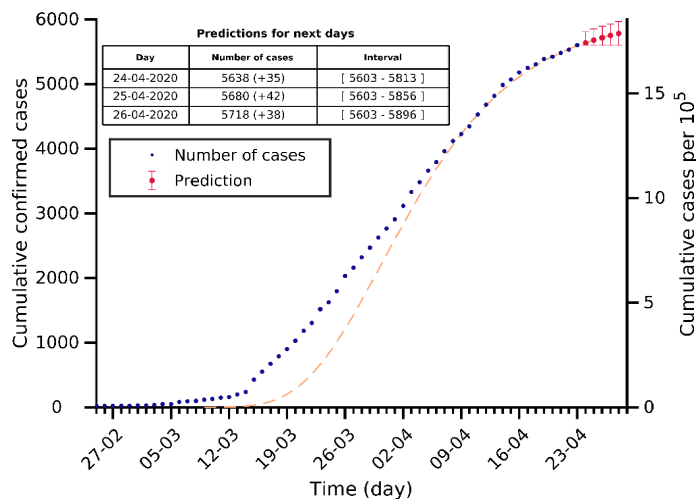
Philippines 23-04-2020. Population: 109.6M. Current cumulated incidence: 6/10⁵



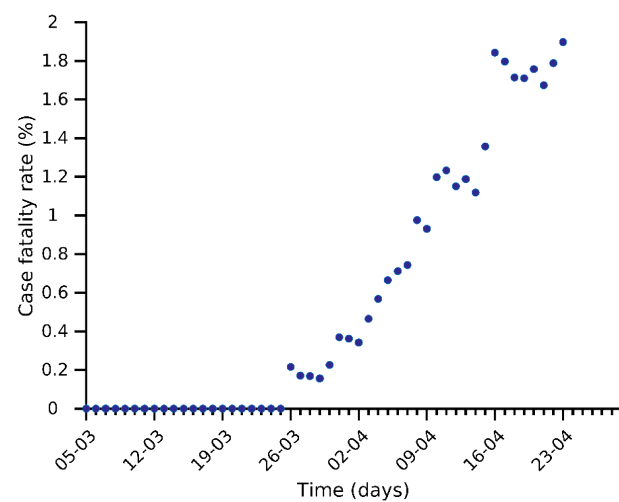
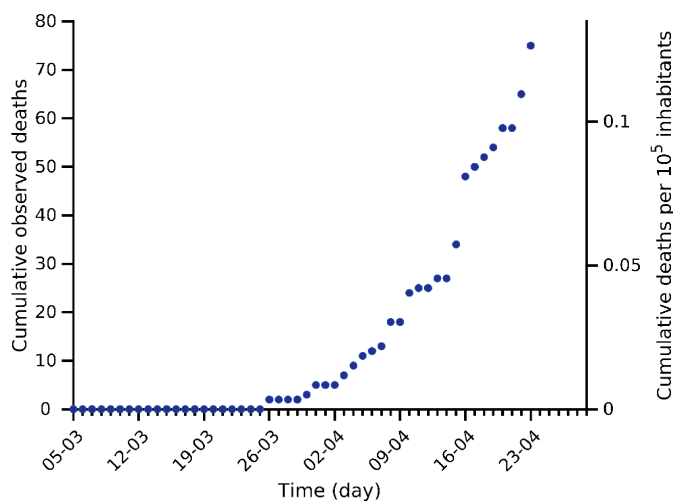
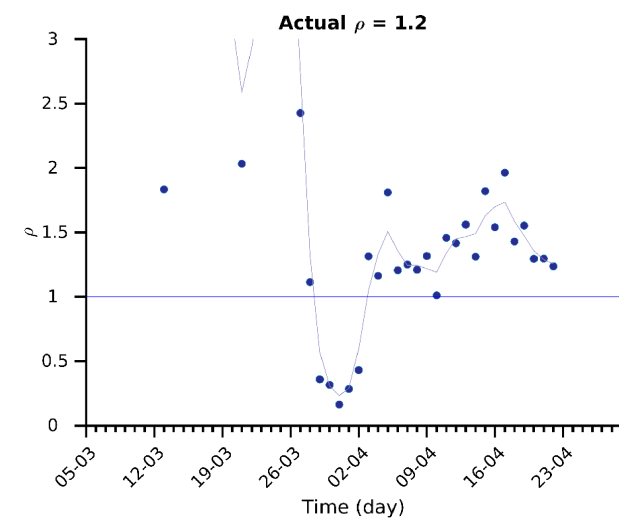
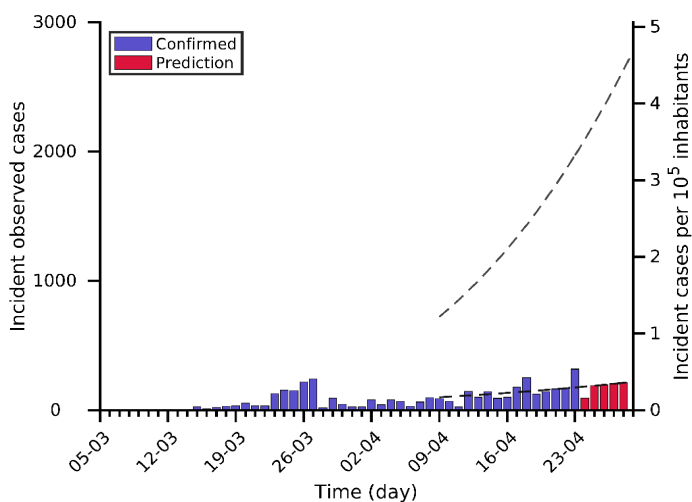
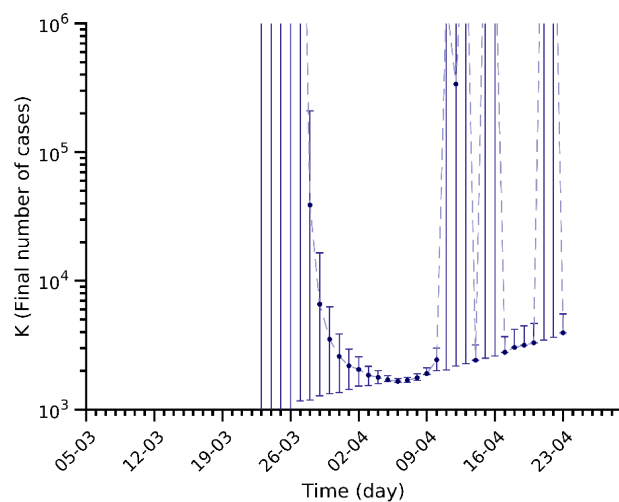
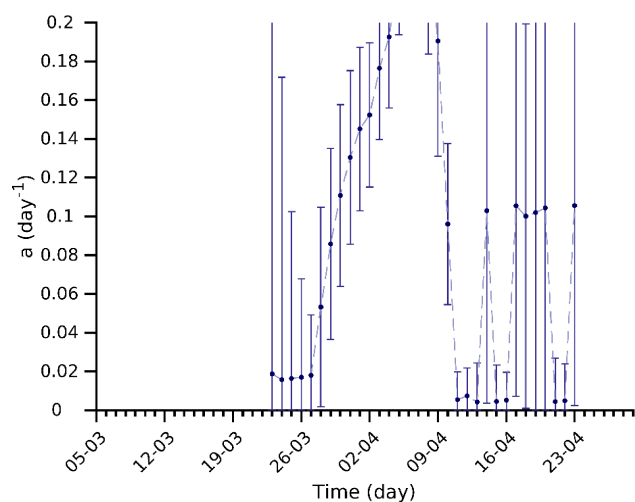
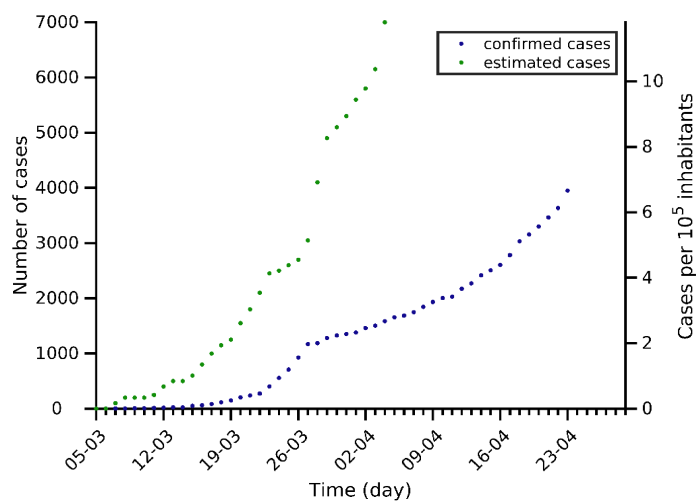
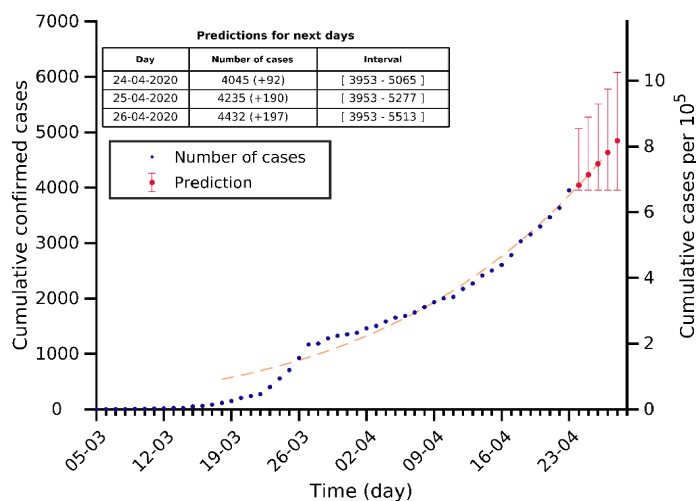
Australia 23-04-2020. Population: 25.5M. Current cumulated incidence: 26/10⁵



Malaysia 23-04-2020. Population: 32.4M. Current cumulated incidence: 17/10⁵



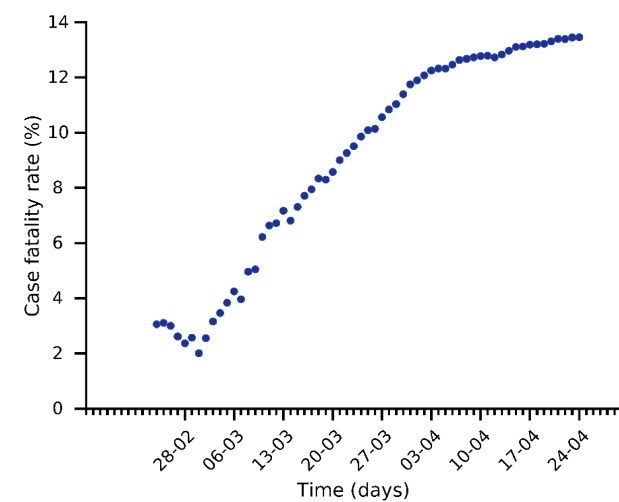
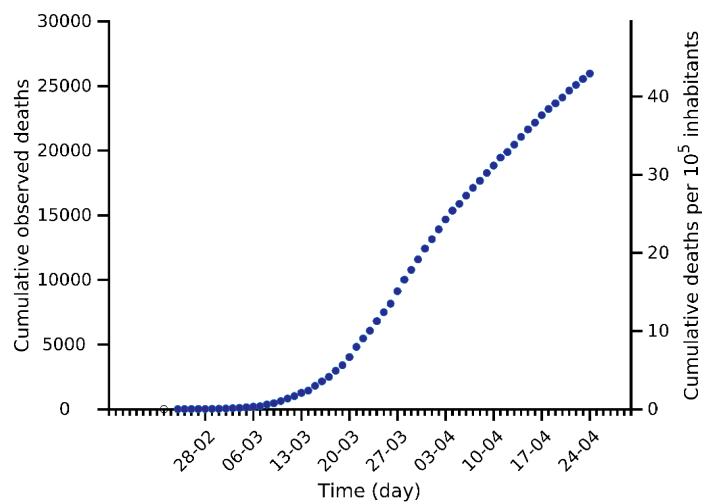
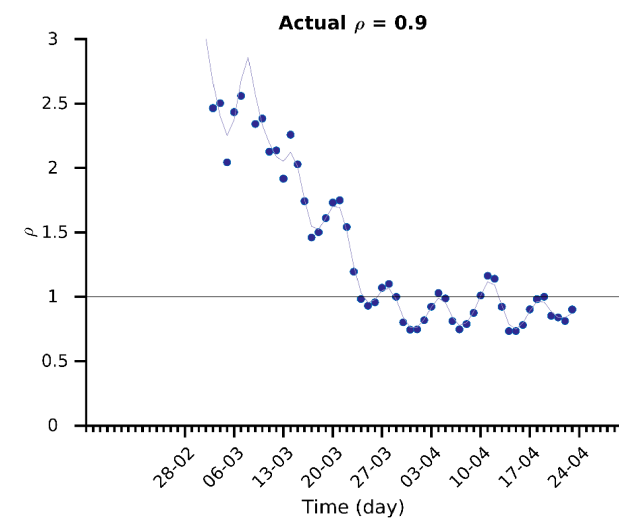
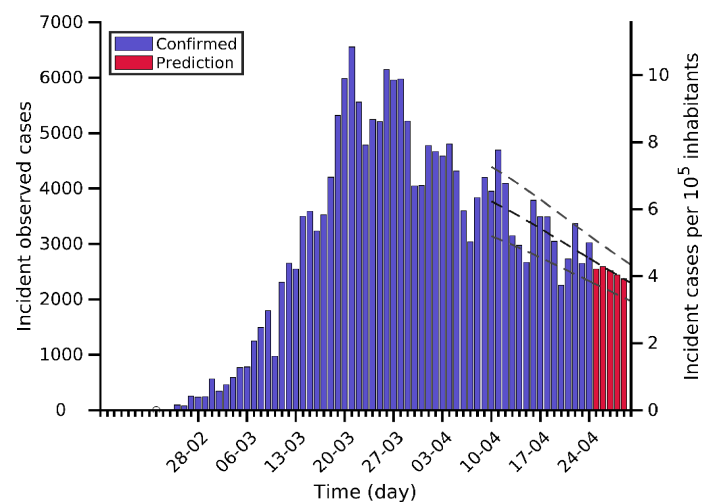
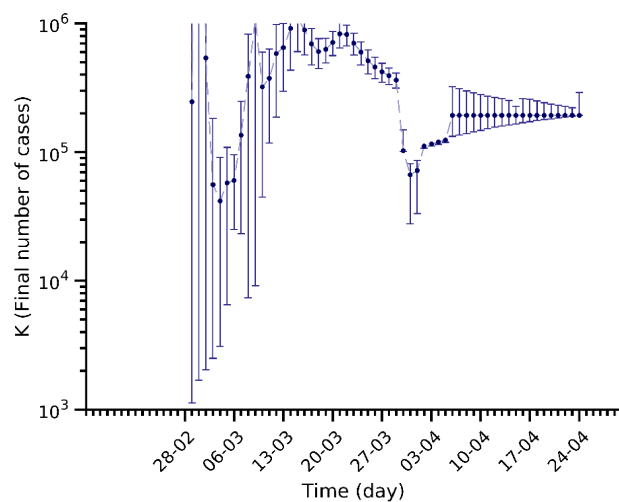
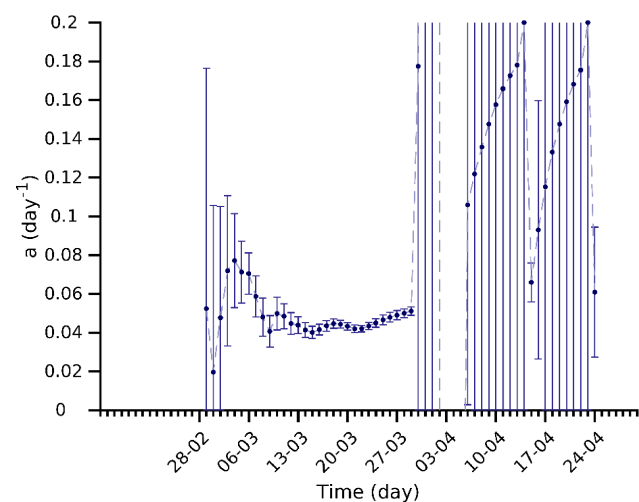
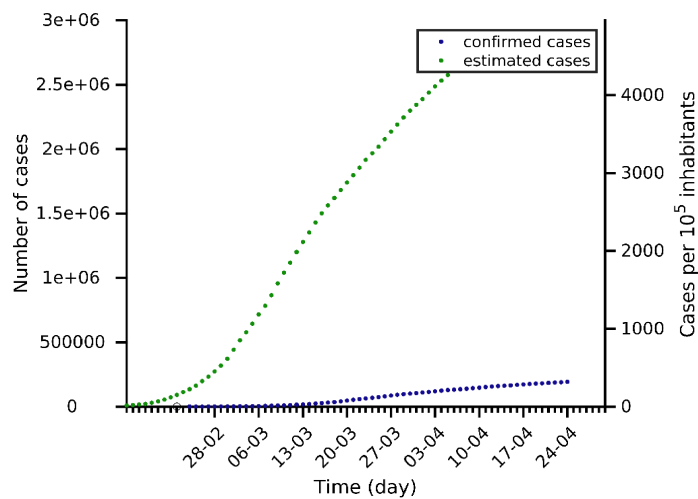
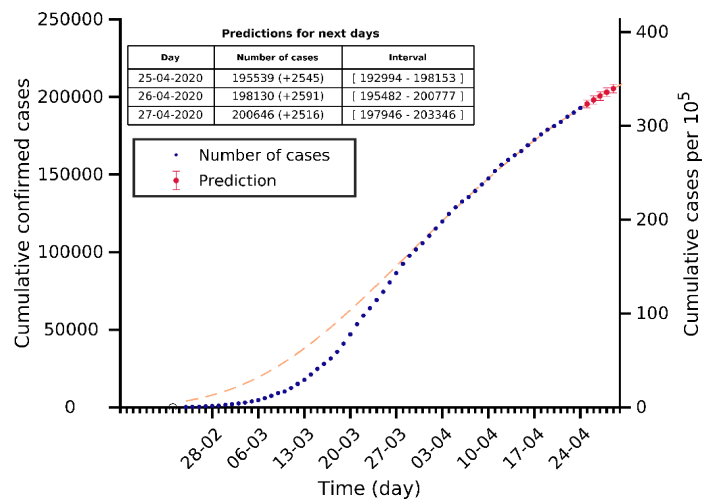
South Africa 23-04-2020. Population: 59.3M. Current cumulated incidence: 7/10⁵



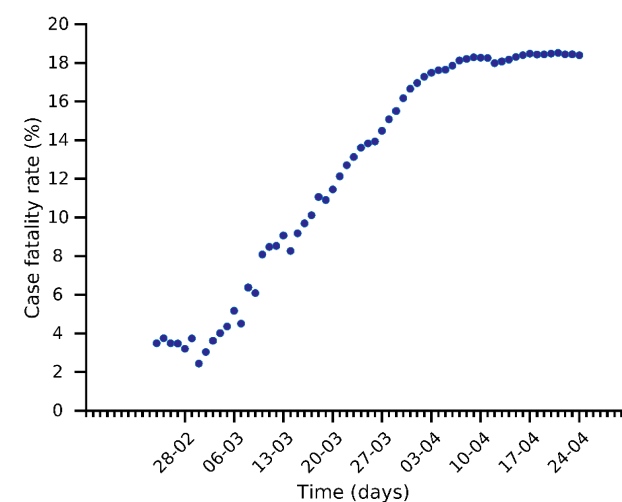
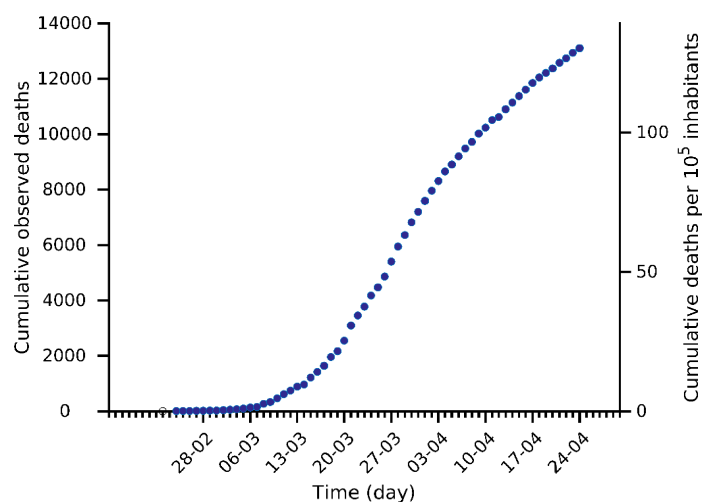
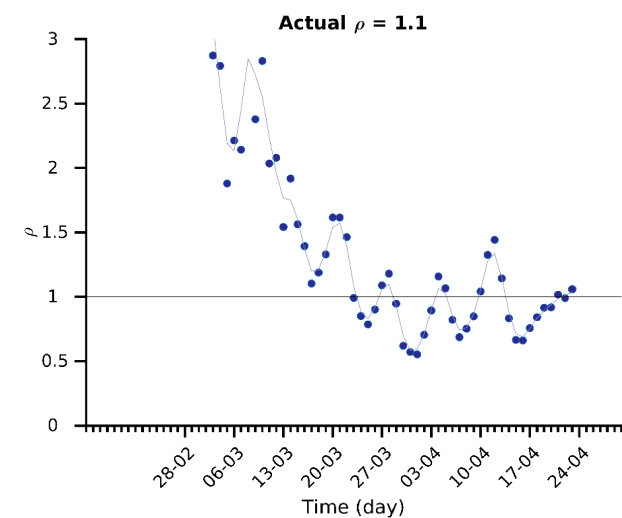
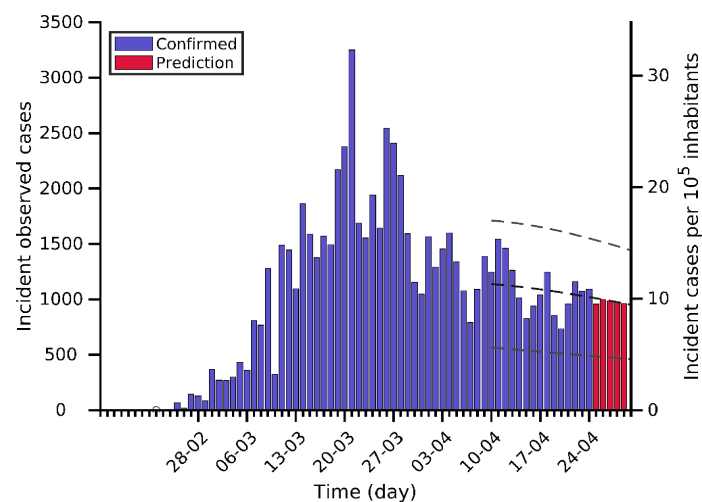
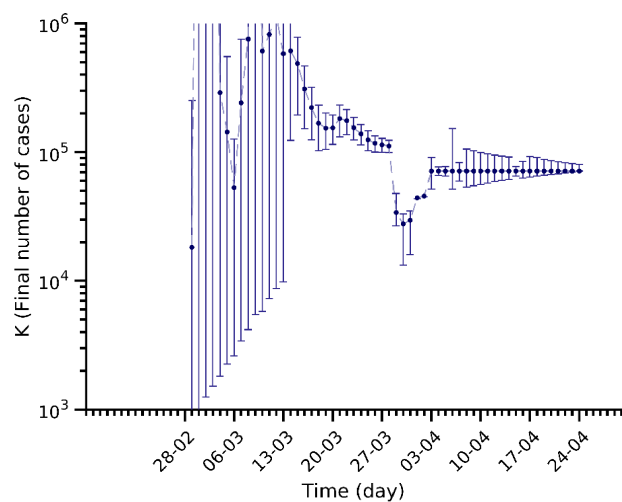
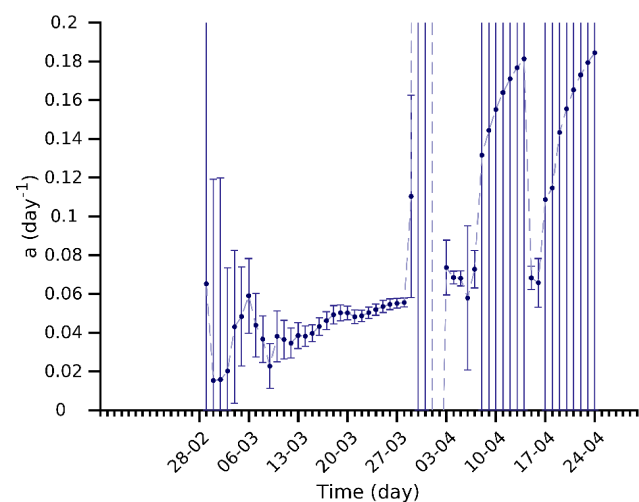
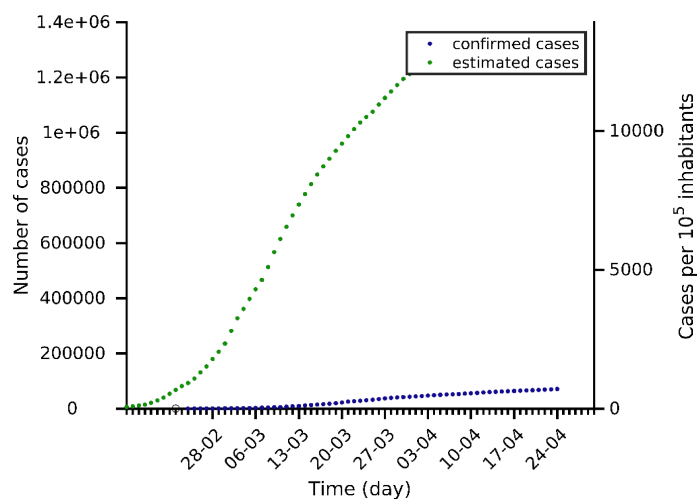
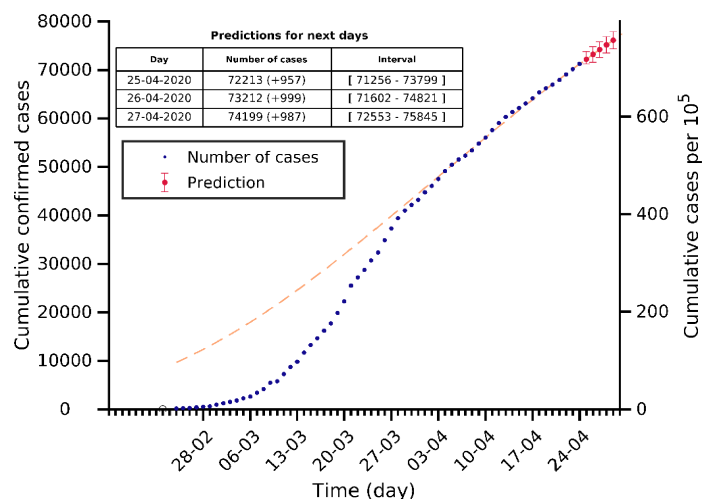
(3) Analysis and prediction of COVID-19 for Italy and its regions

Data obtained from: <https://github.com/pcm-dpc/COVID-19/tree/master/dati-andamento-nazionale>

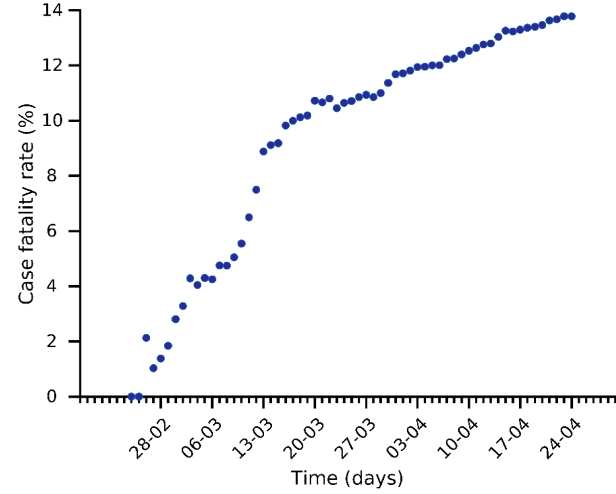
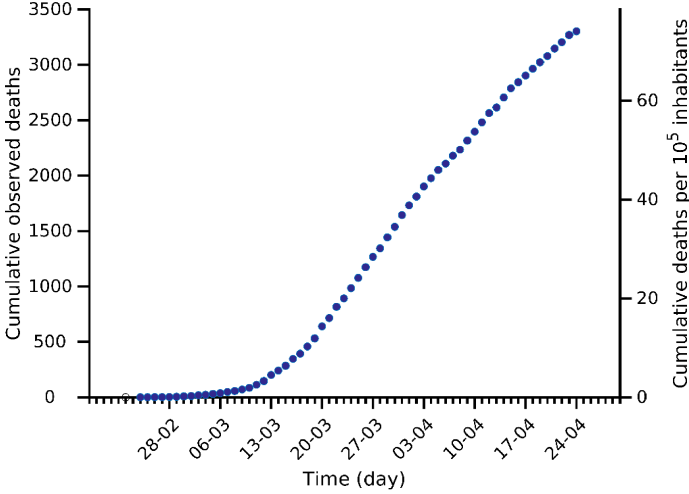
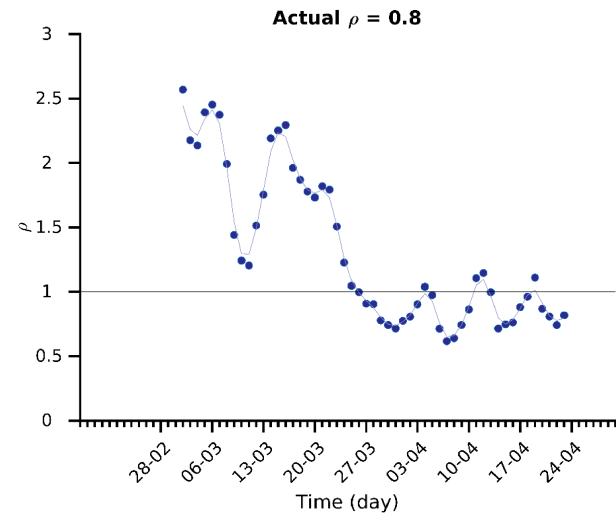
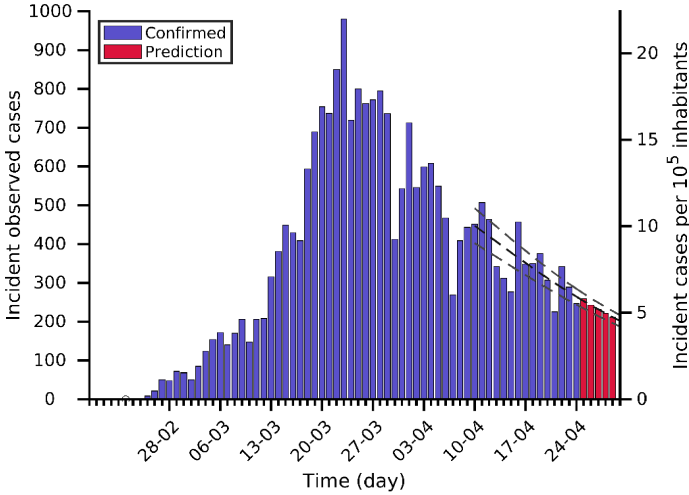
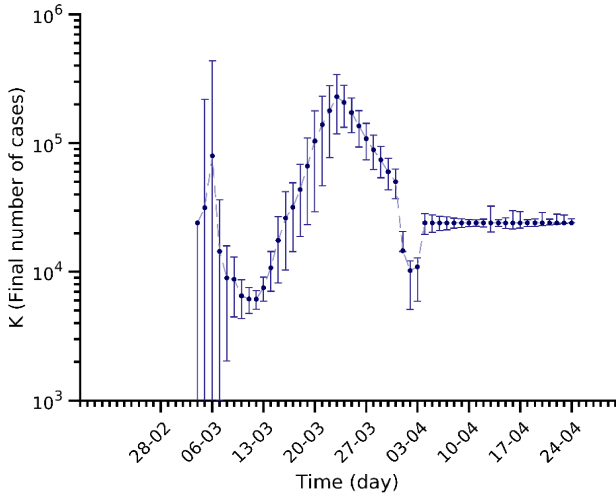
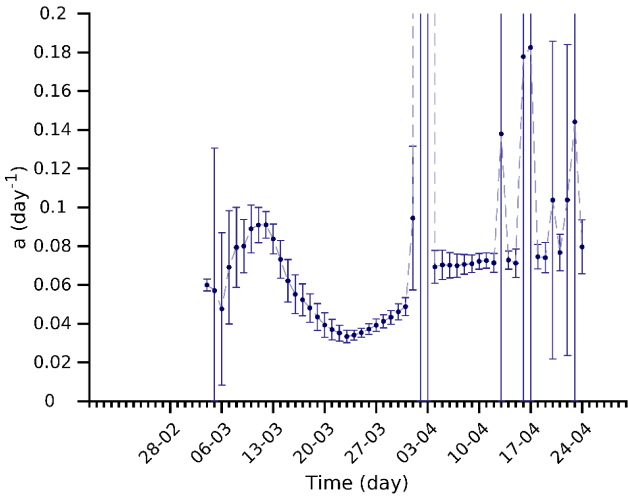
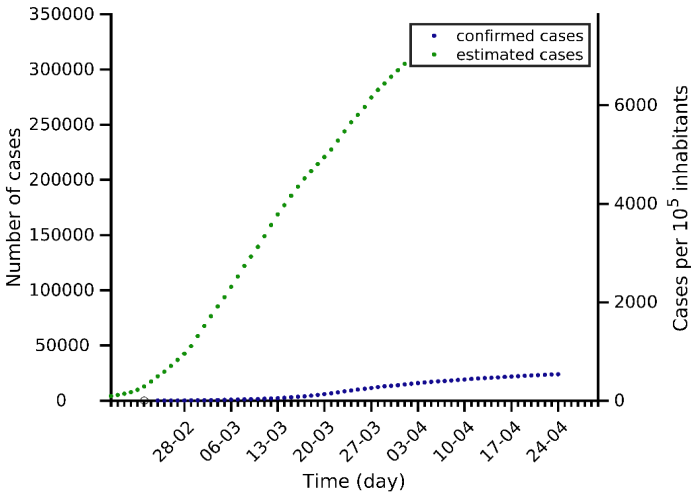
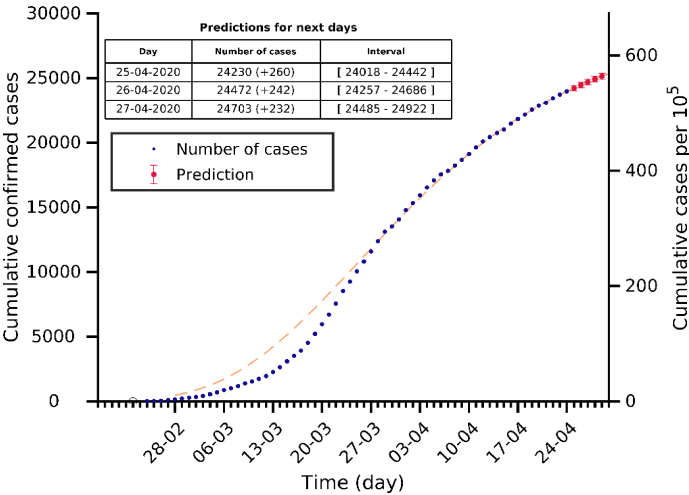
Italy 24-04-2020. Population: 60.5M. Current cumulated incidence: 319/10⁵



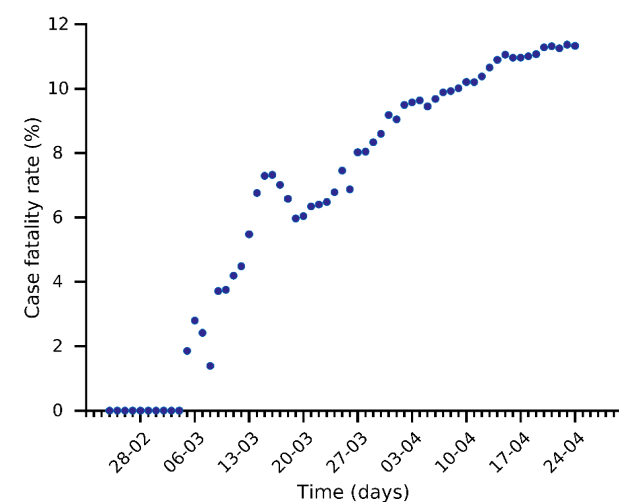
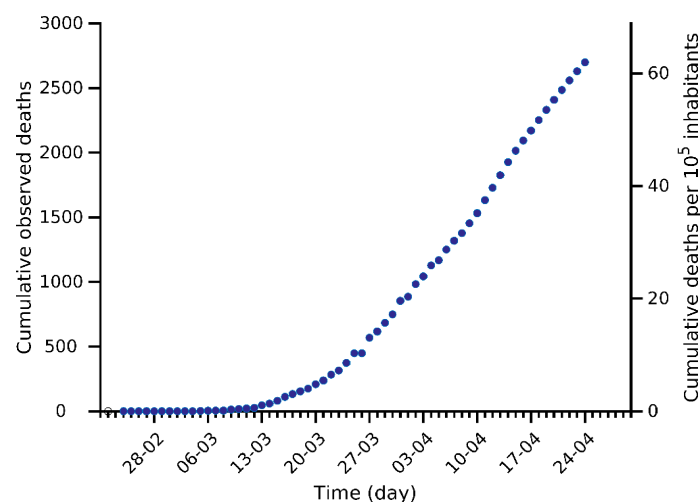
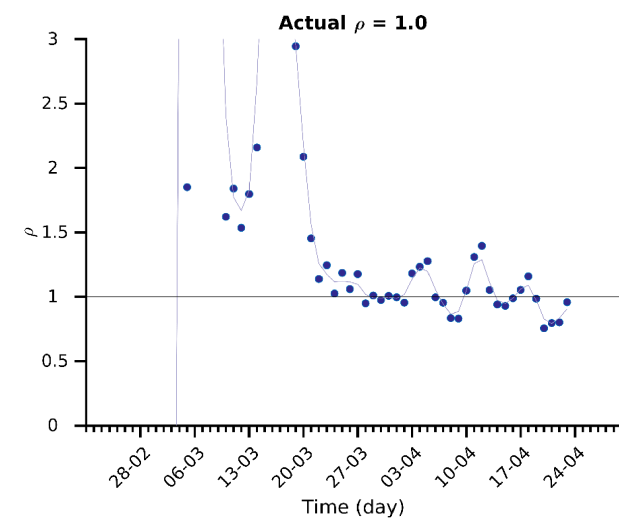
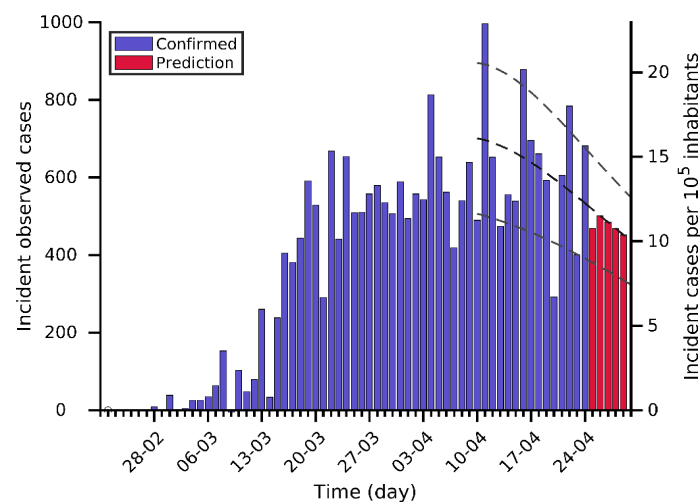
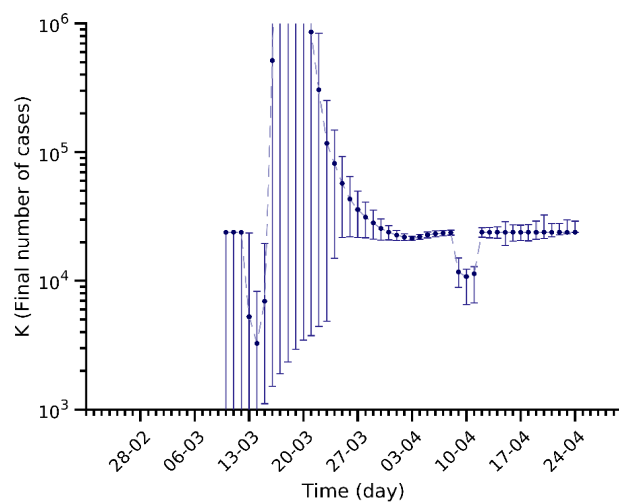
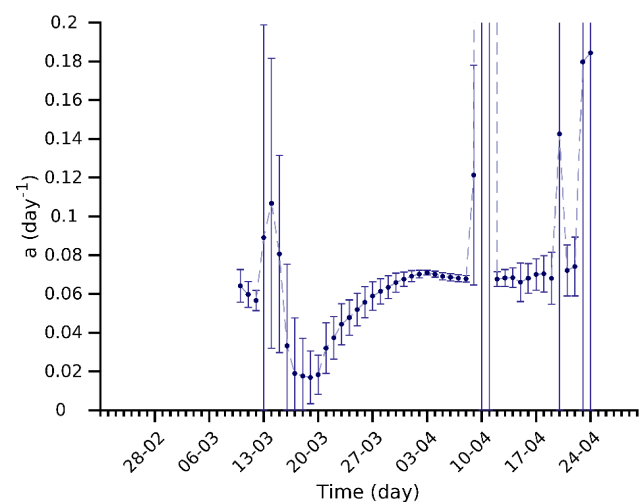
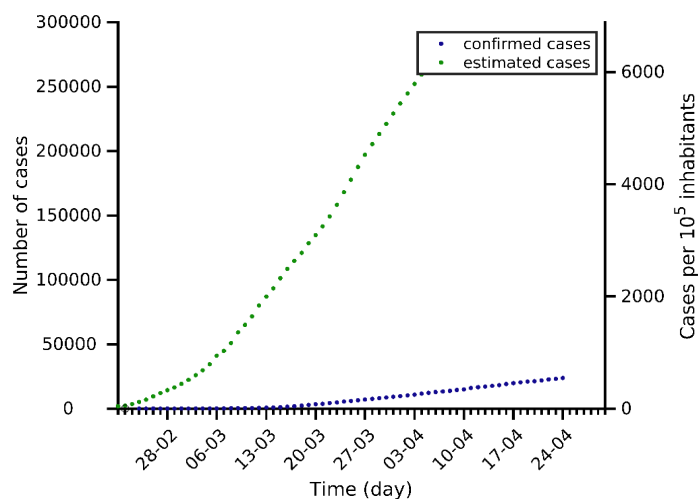
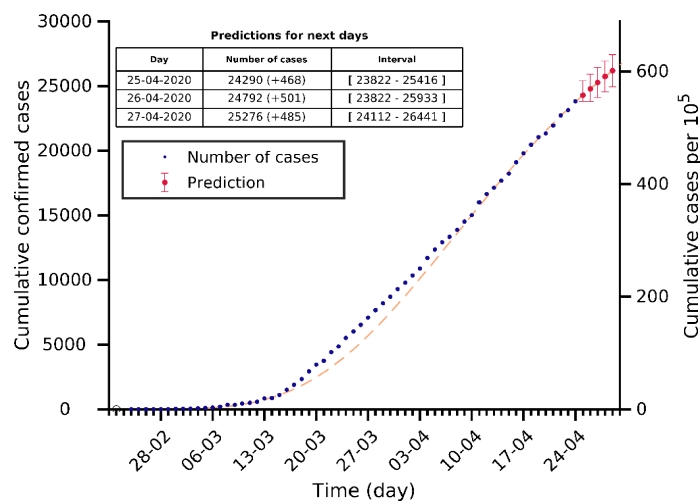
Lombardia 24-04-2020. Population: 10.1M. Current cumulated incidence: 708/10⁵



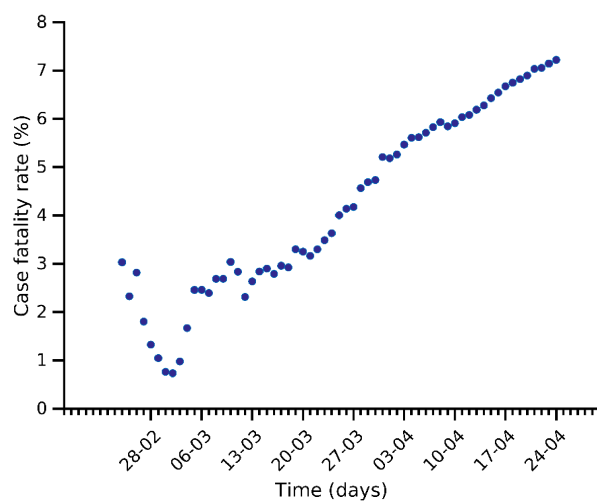
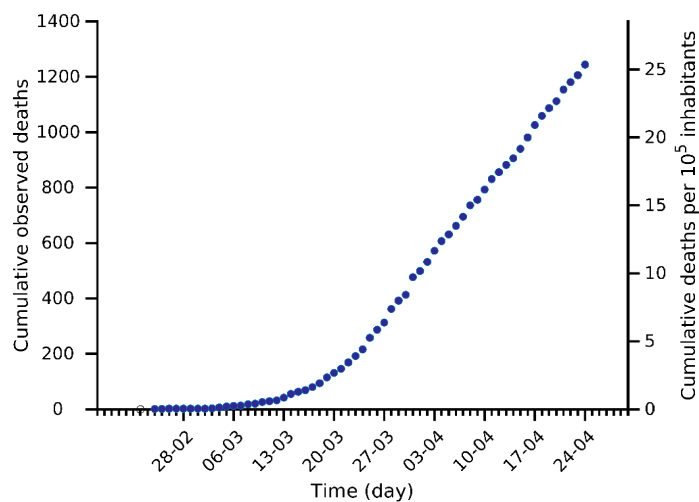
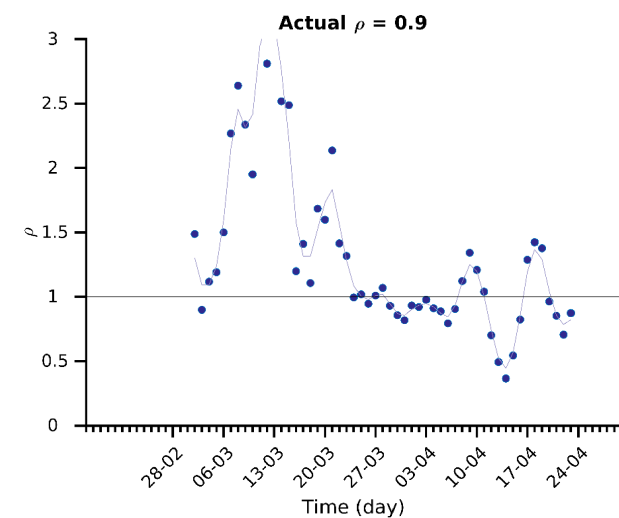
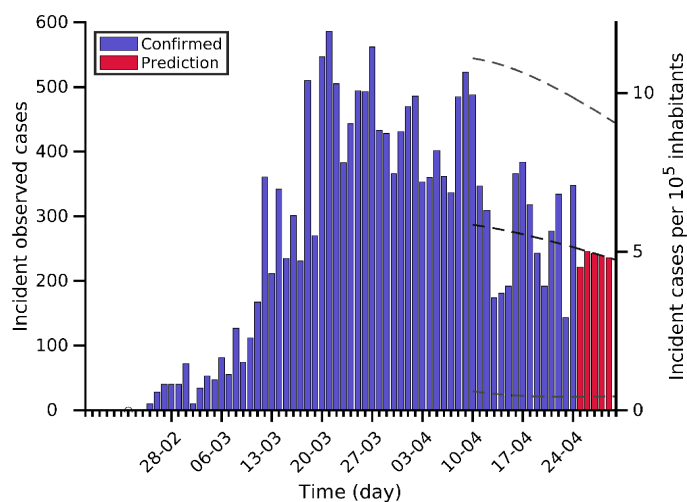
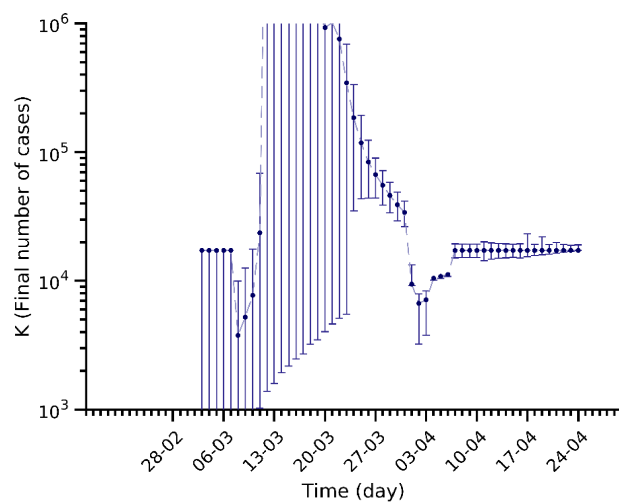
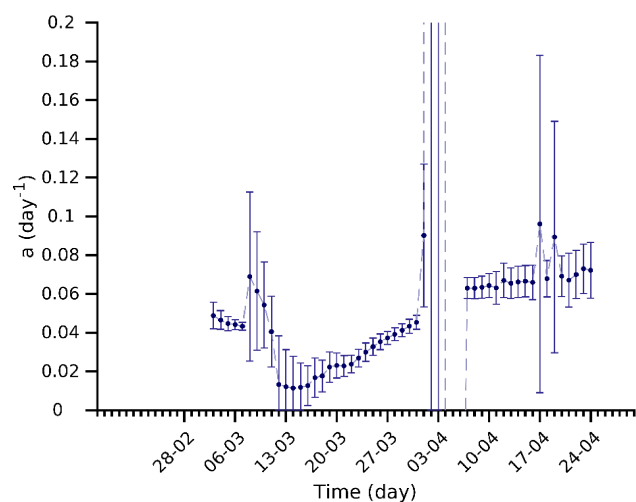
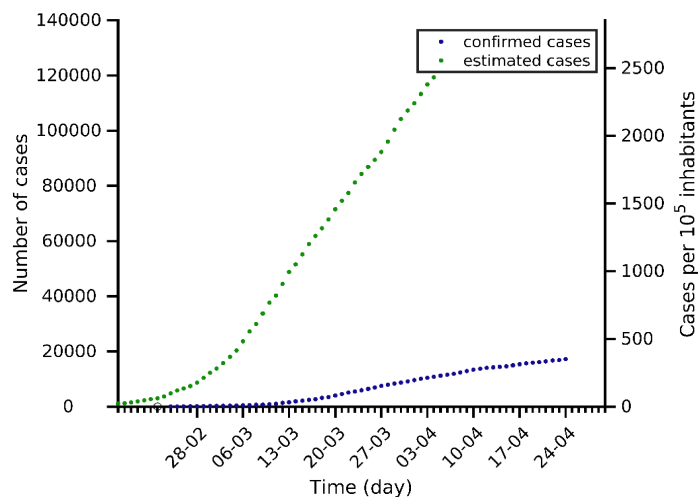
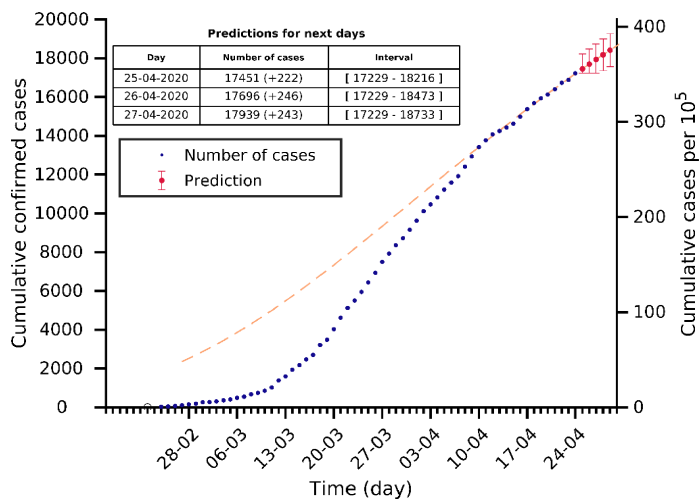
Emilia Romagna 24-04-2020. Population: 4.5M. Current cumulated incidence: 538/10⁵



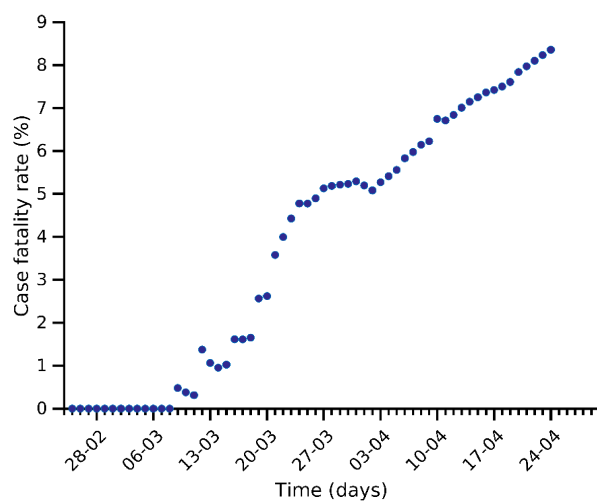
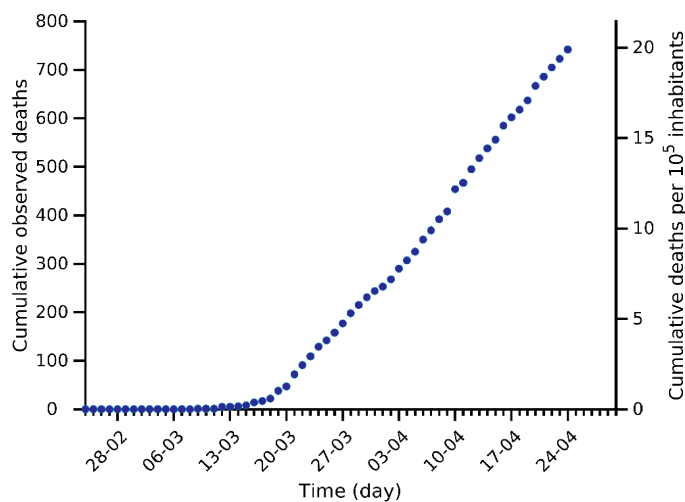
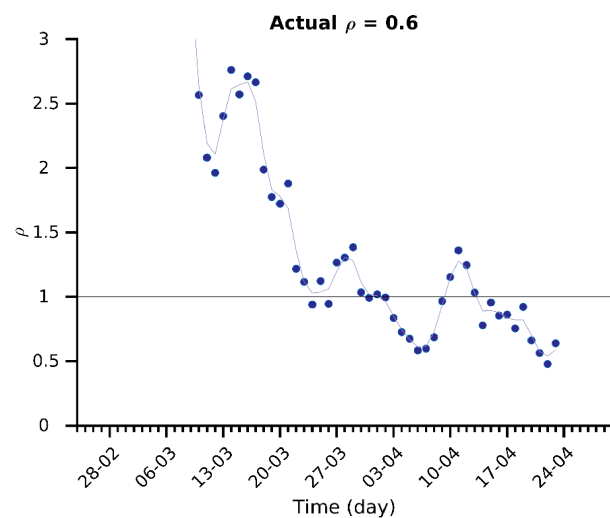
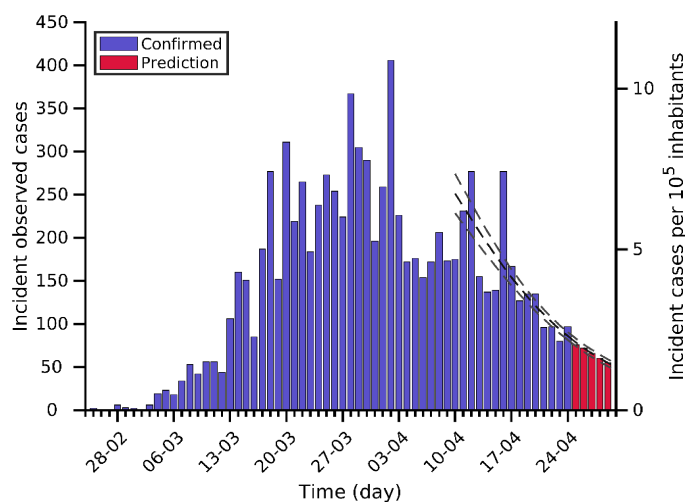
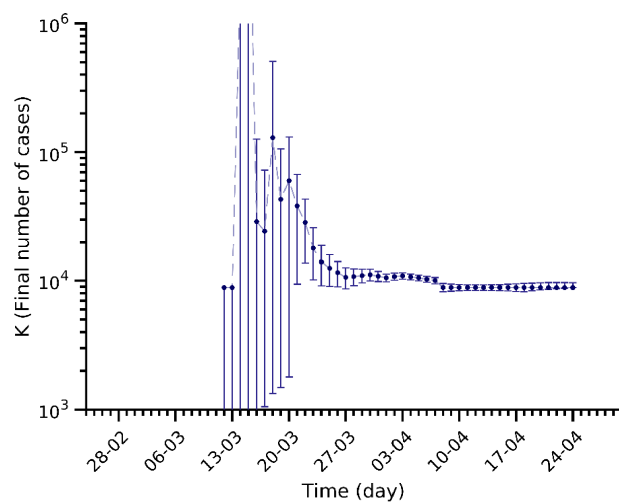
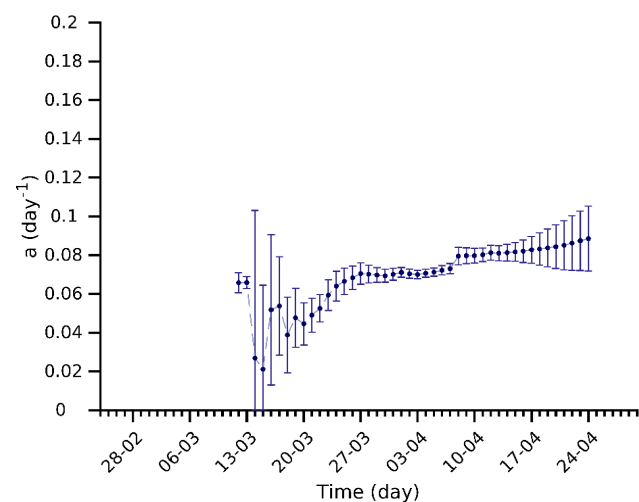
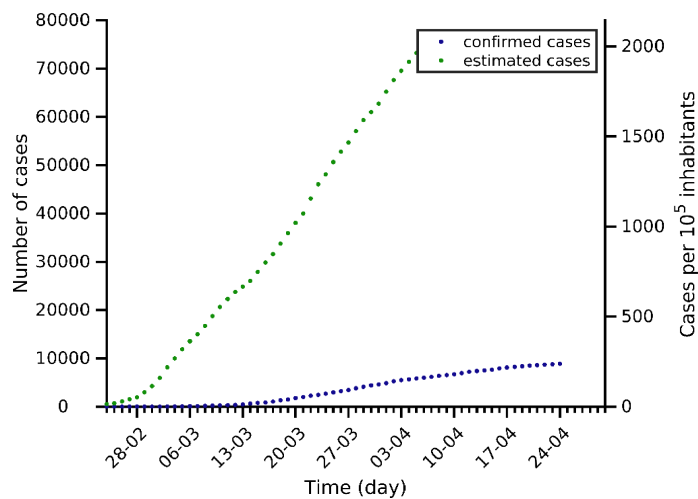
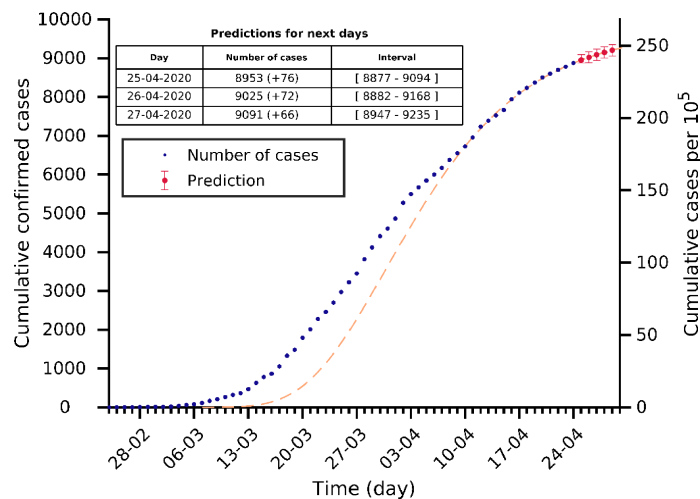
Piemonte 24-04-2020. Population: 4.4M. Current cumulated incidence: 547/10⁵



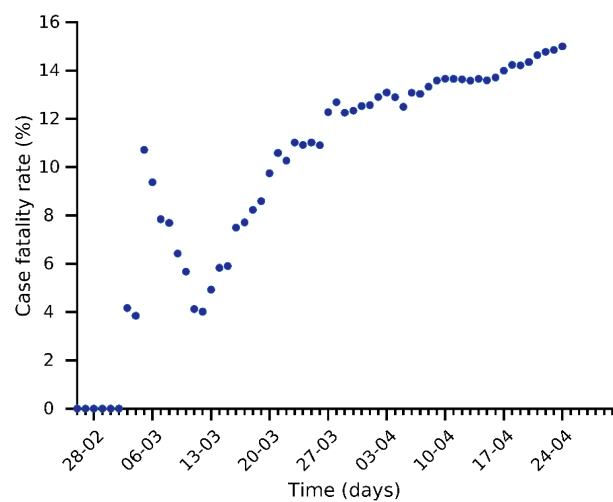
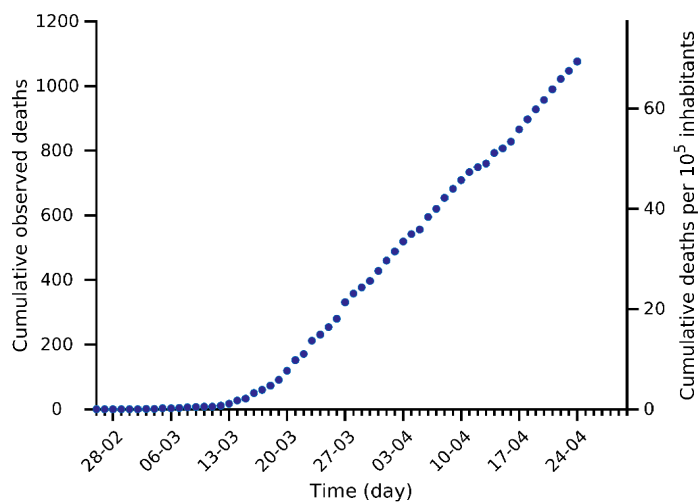
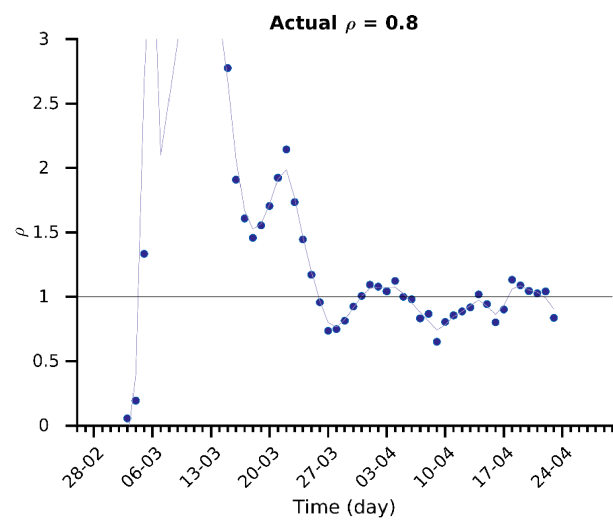
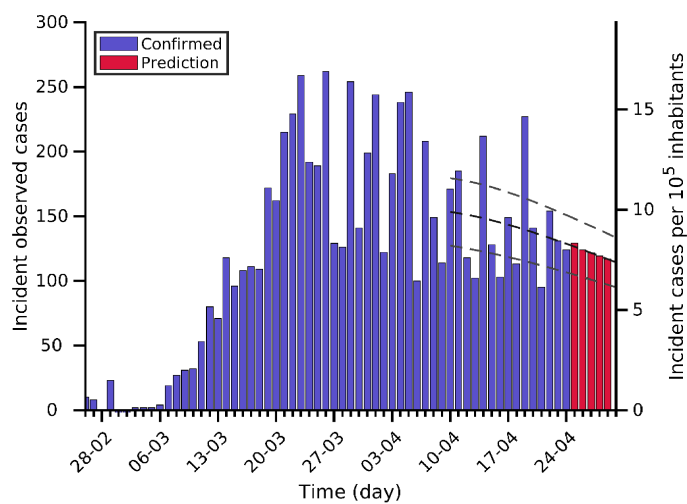
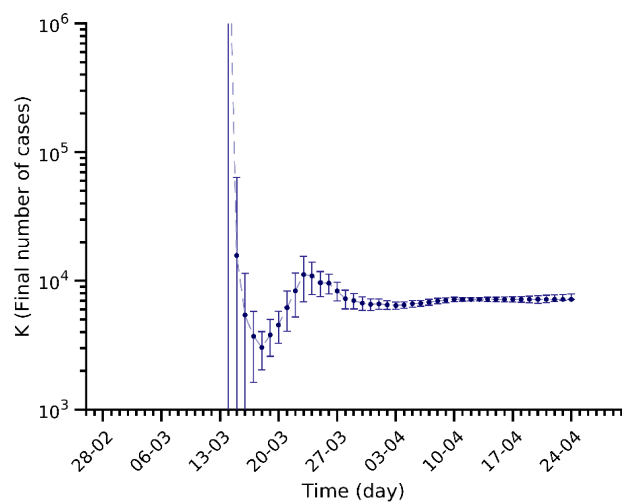
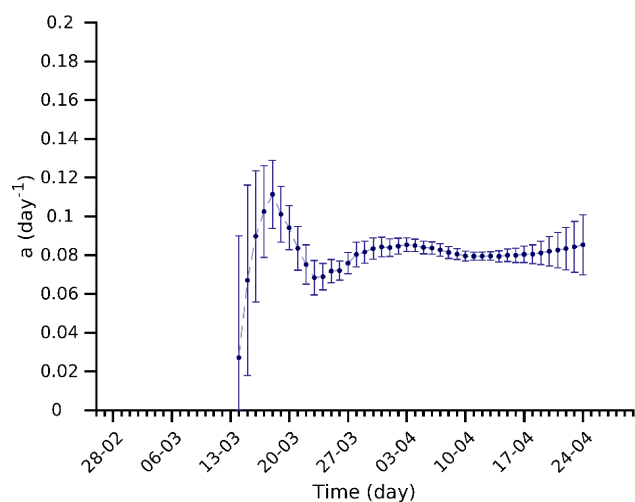
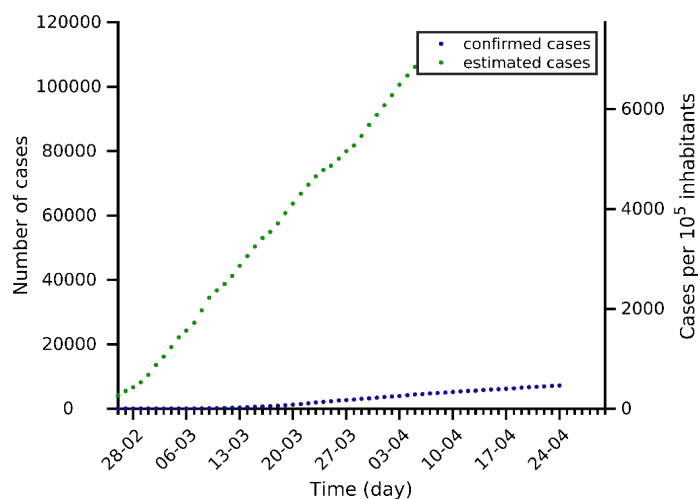
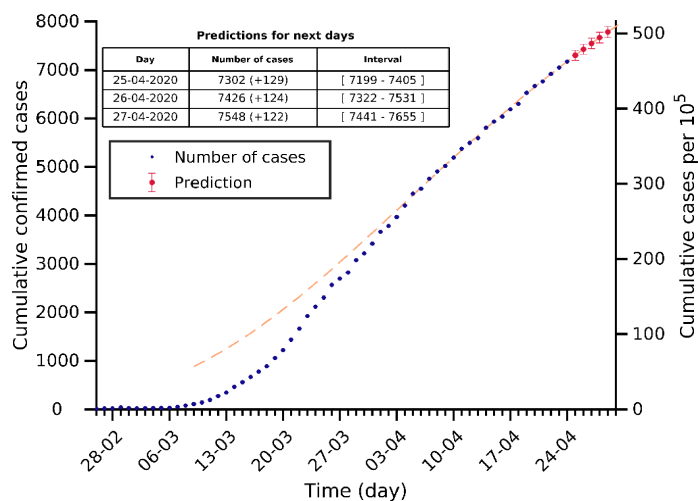
Veneto 24-04-2020. Population: 4.9M. Current cumulated incidence: 351/10⁵



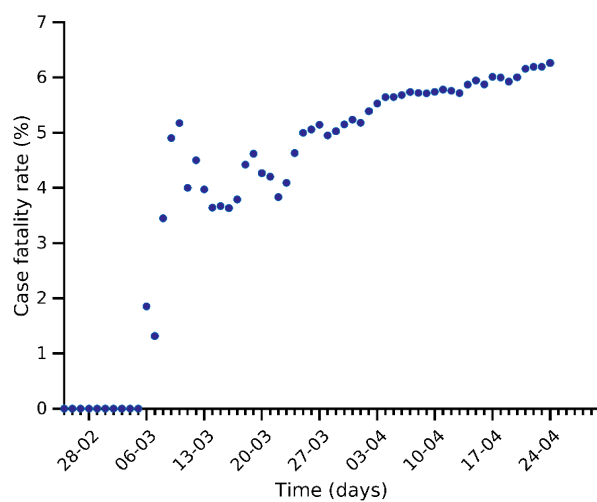
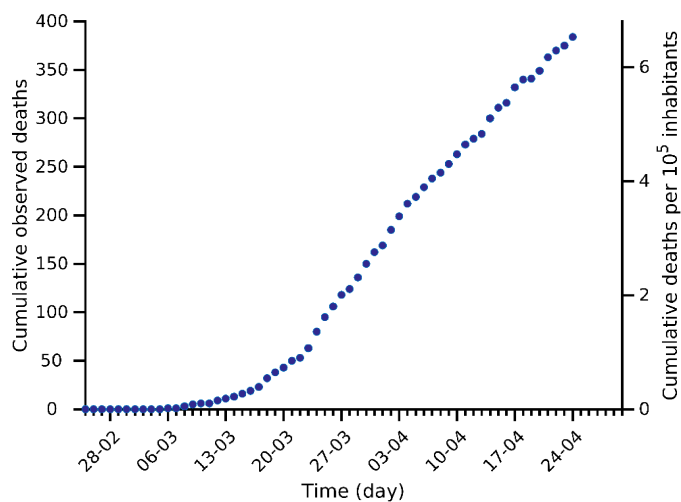
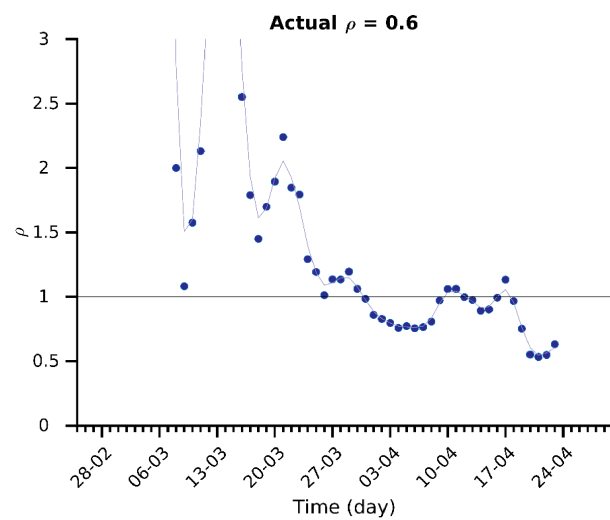
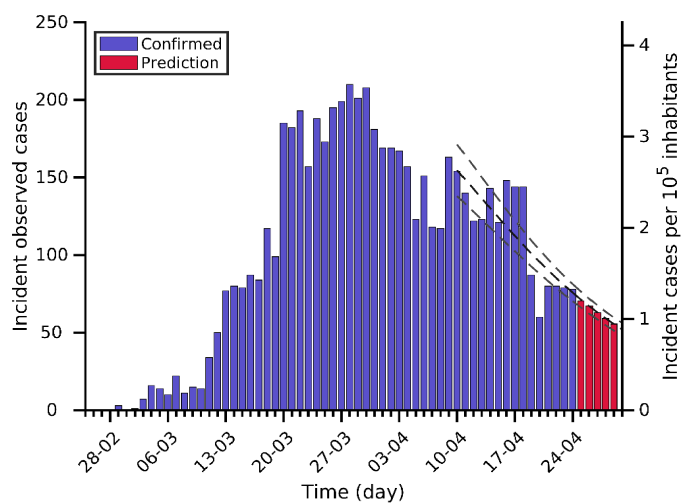
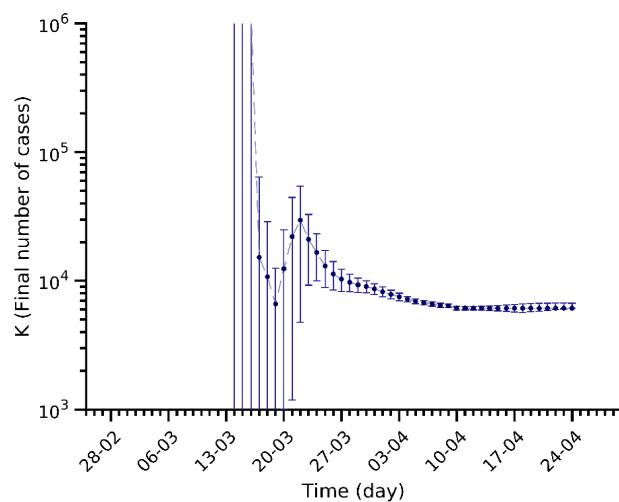
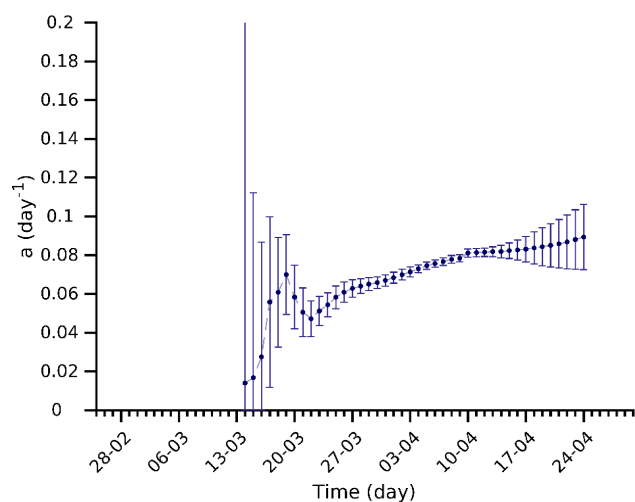
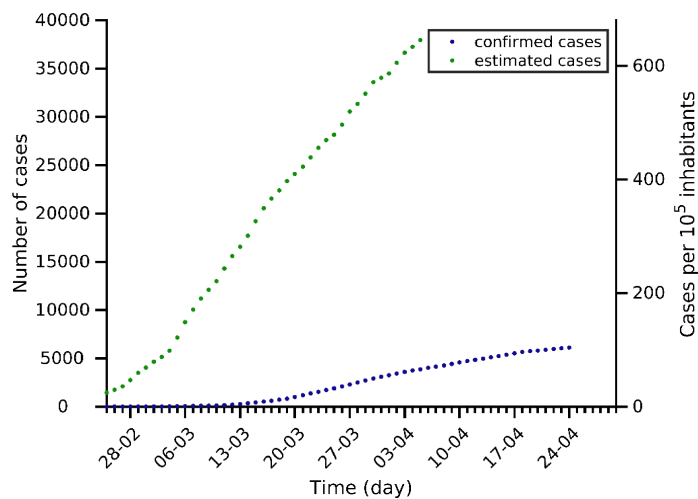
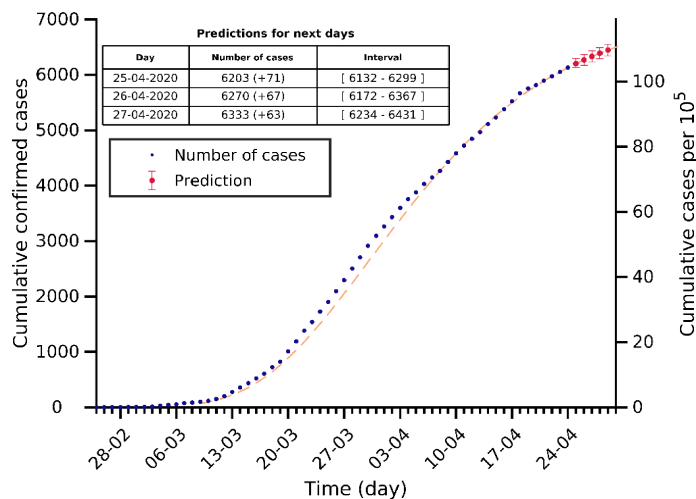
Toscana 24-04-2020. Population: 3.7M. Current cumulated incidence: 238/10⁵



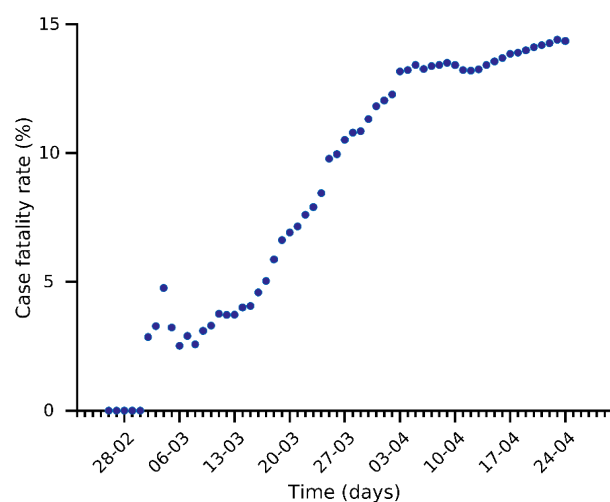
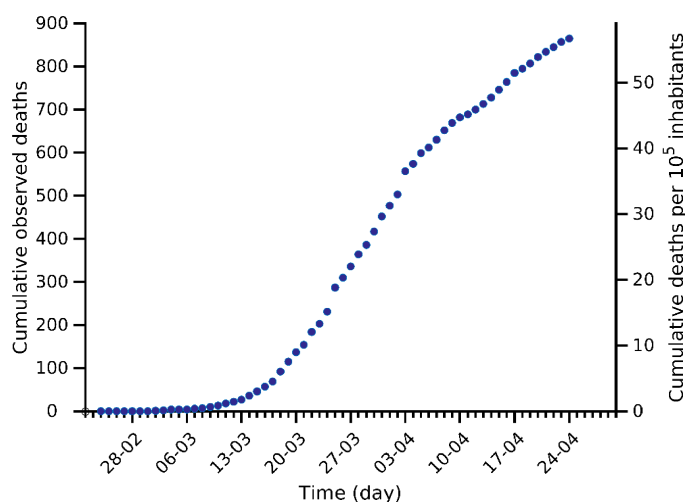
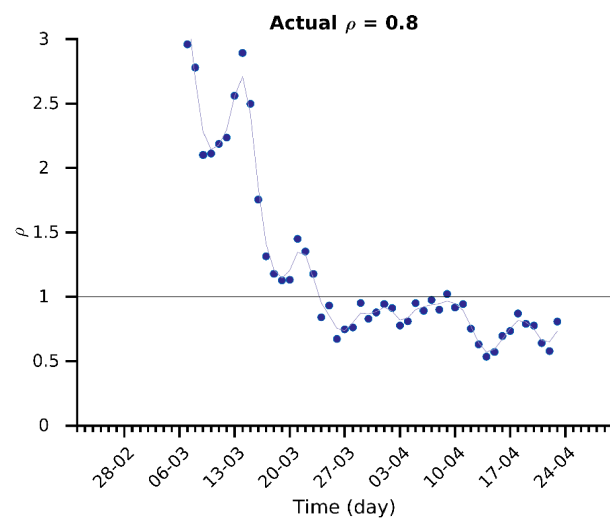
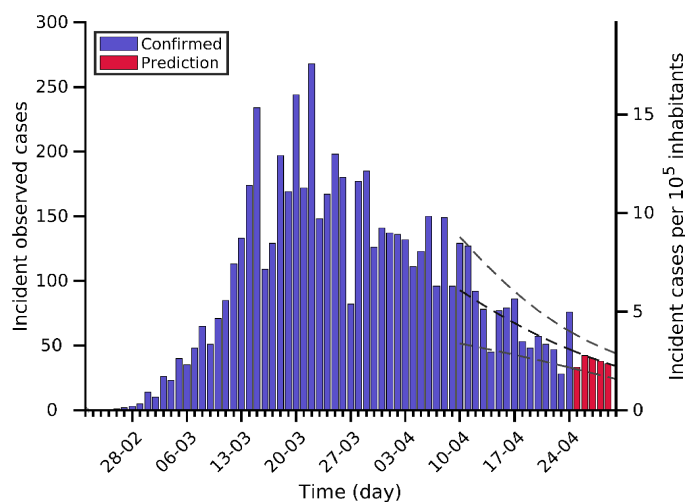
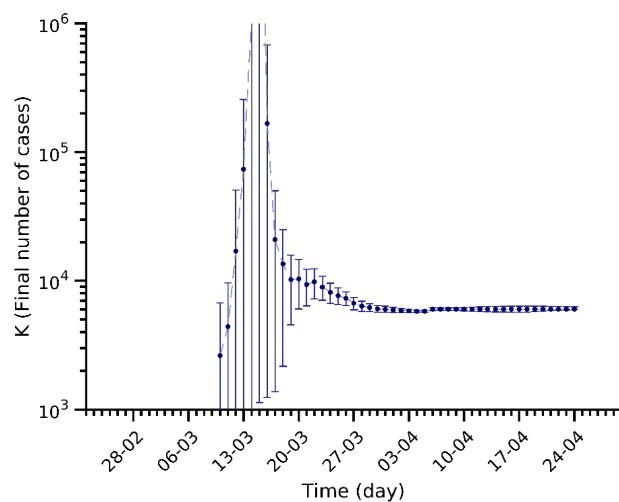
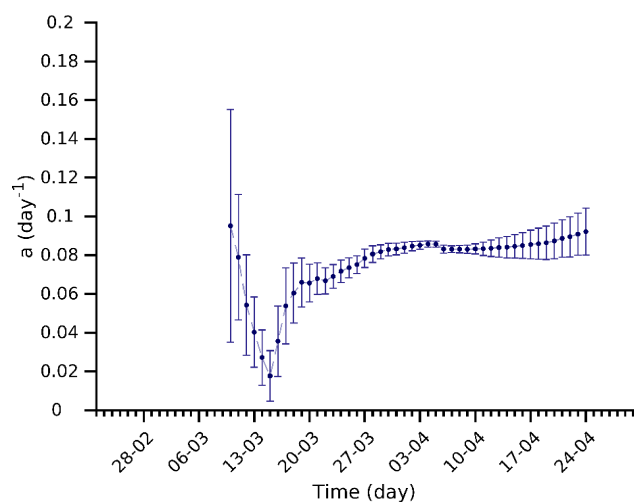
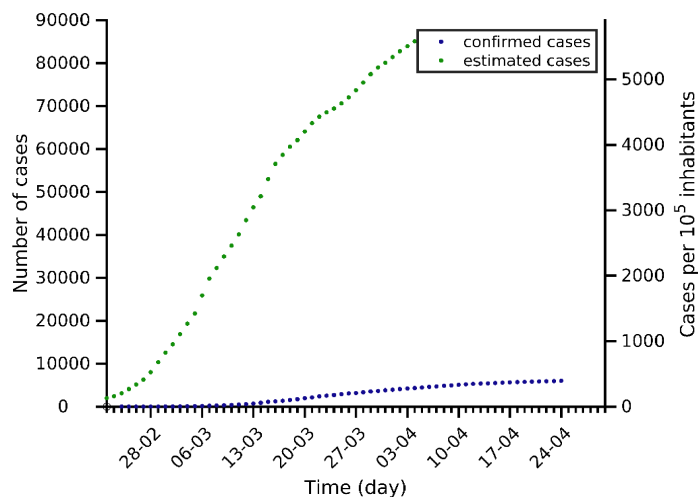
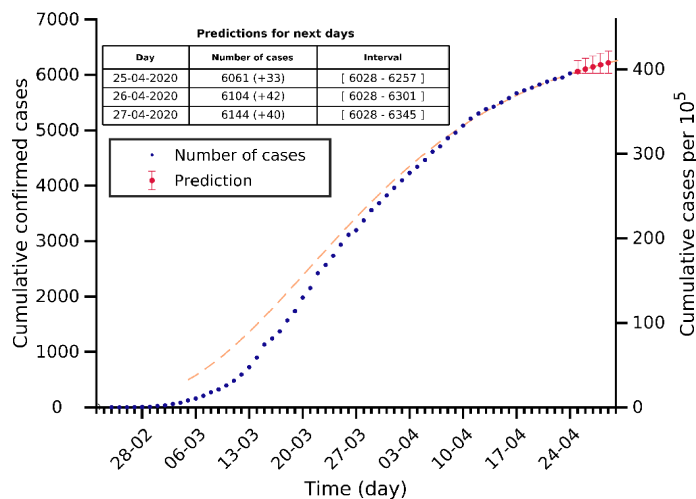
Liguria 24-04-2020. Population: 1.6M. Current cumulated incidence: 462/10⁵



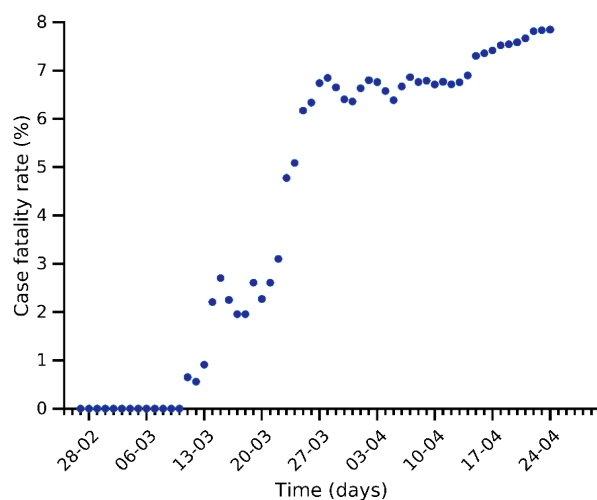
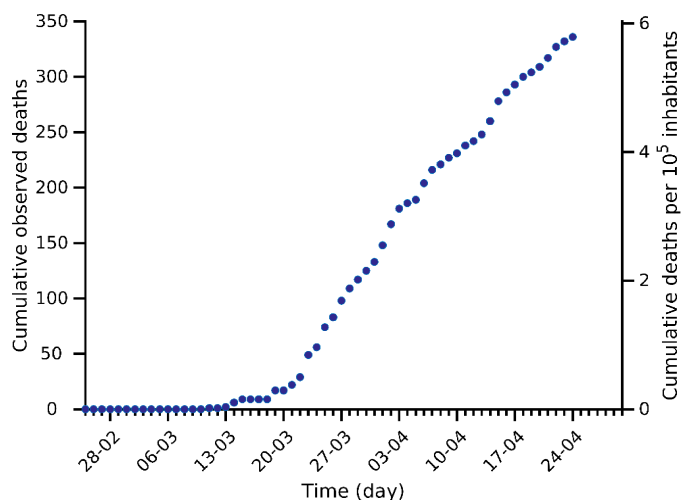
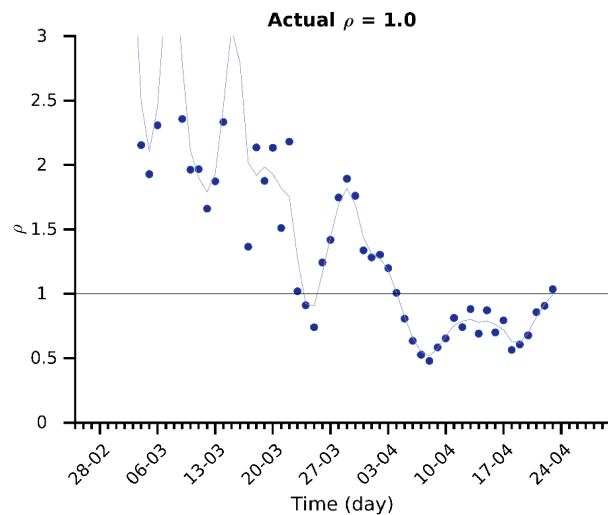
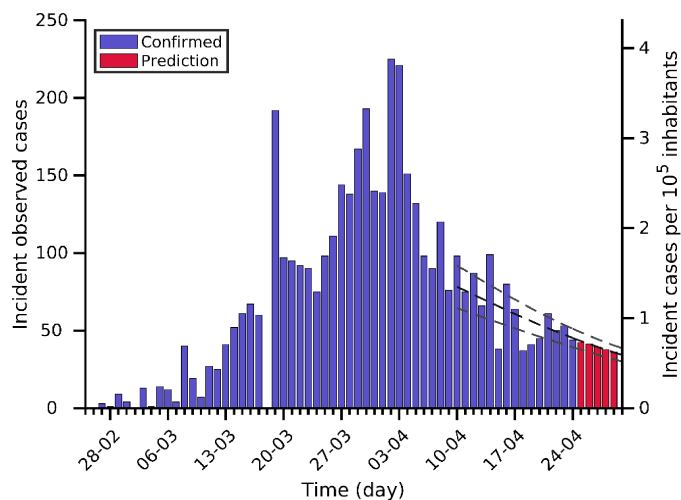
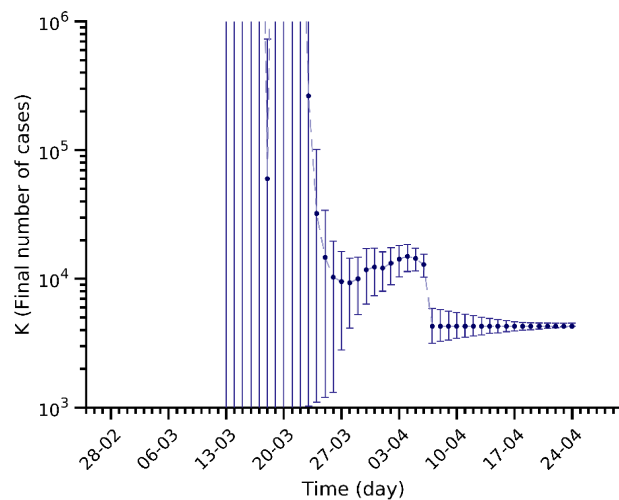
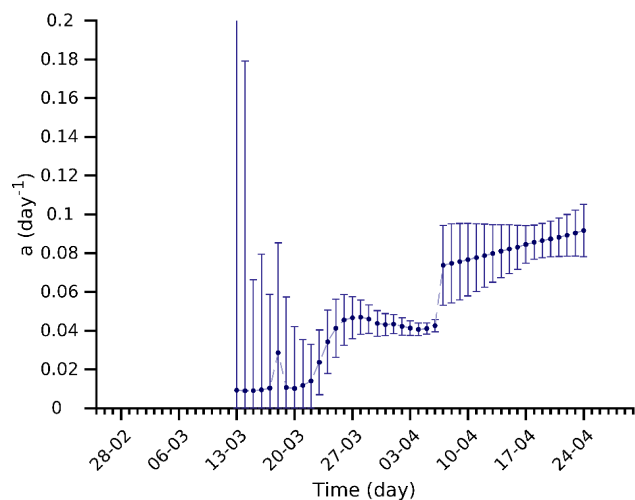
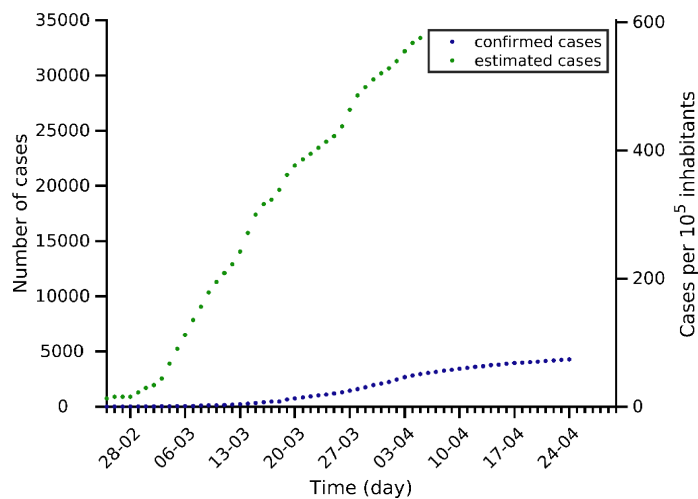
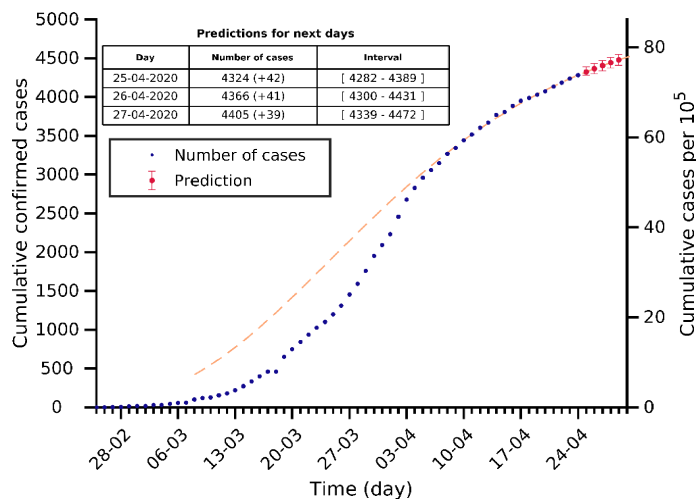
Lazio 24-04-2020. Population: 5.9M. Current cumulated incidence: 104/10⁵



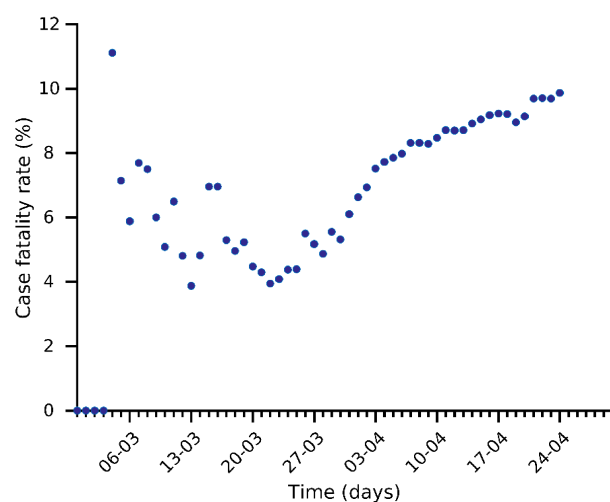
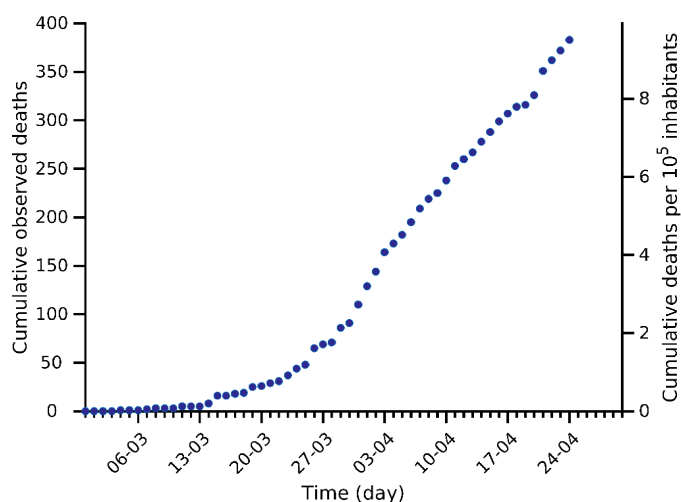
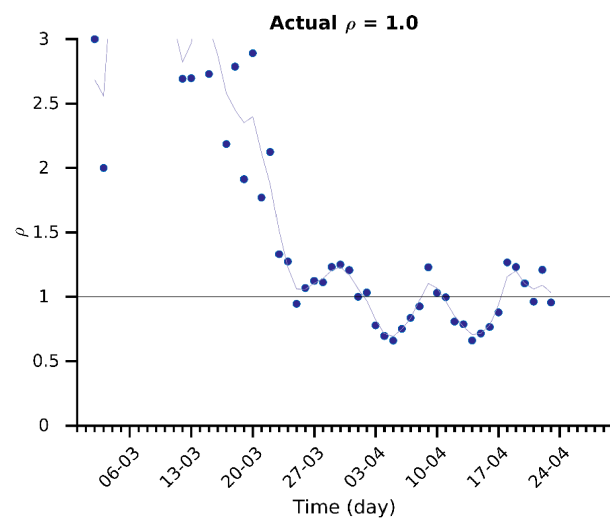
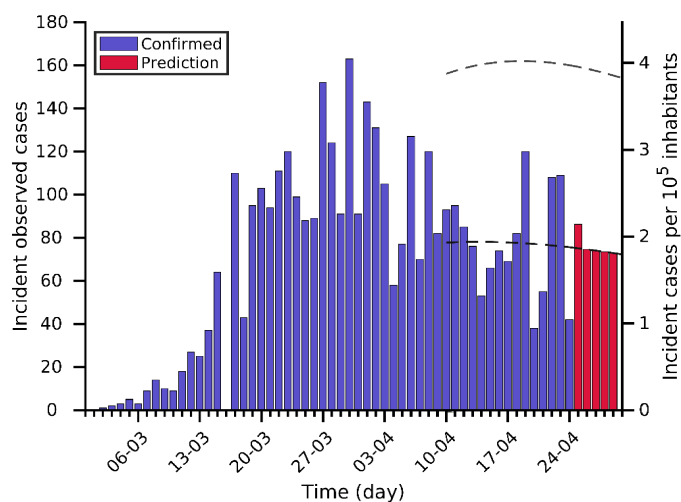
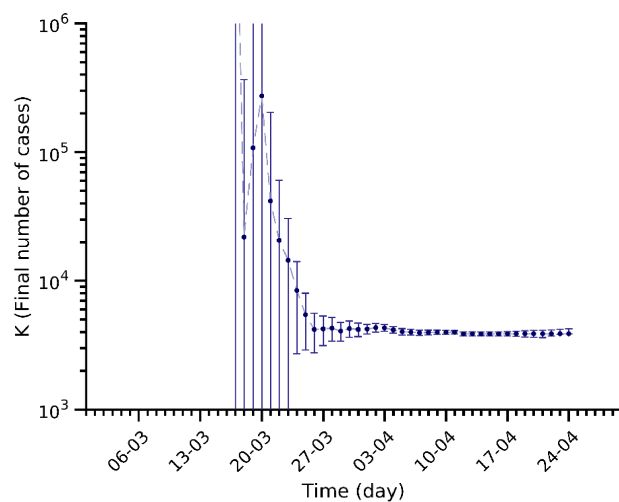
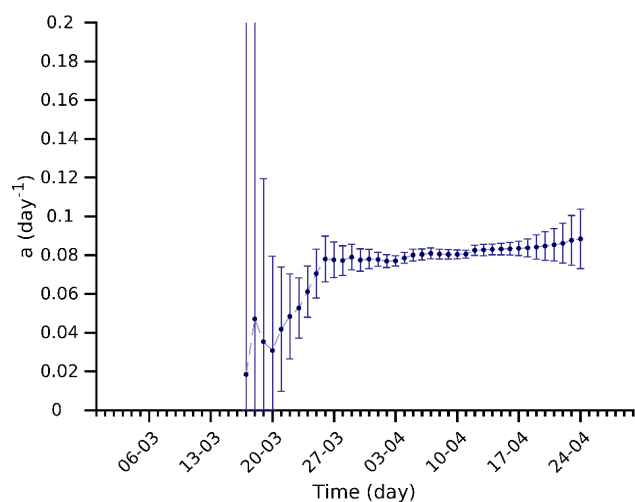
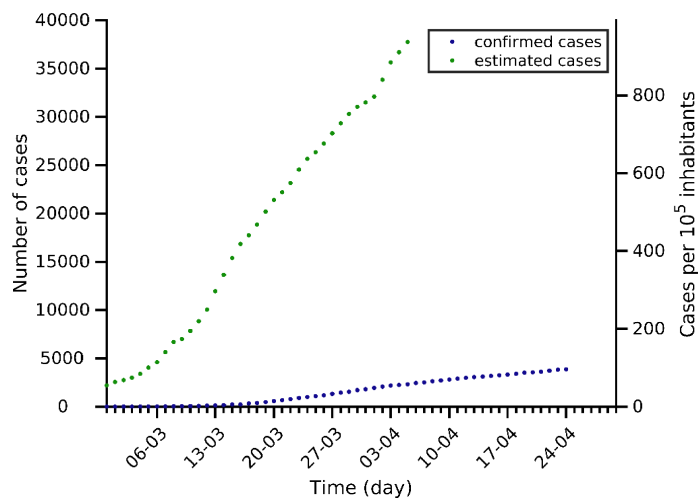
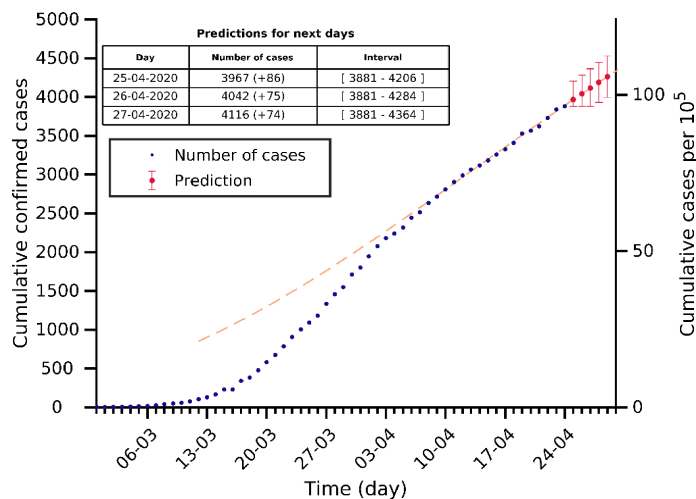
Marche 24-04-2020. Population: 1.5M. Current cumulated incidence: 395/10⁵



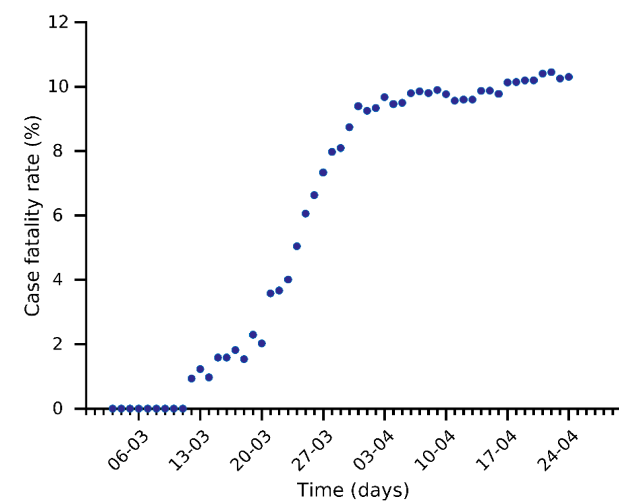
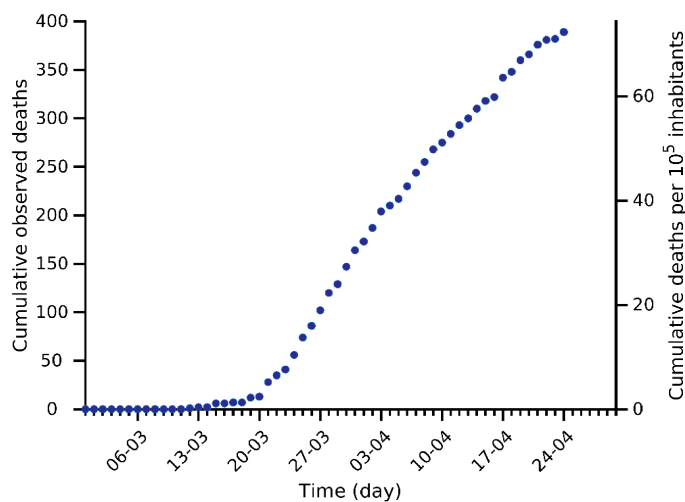
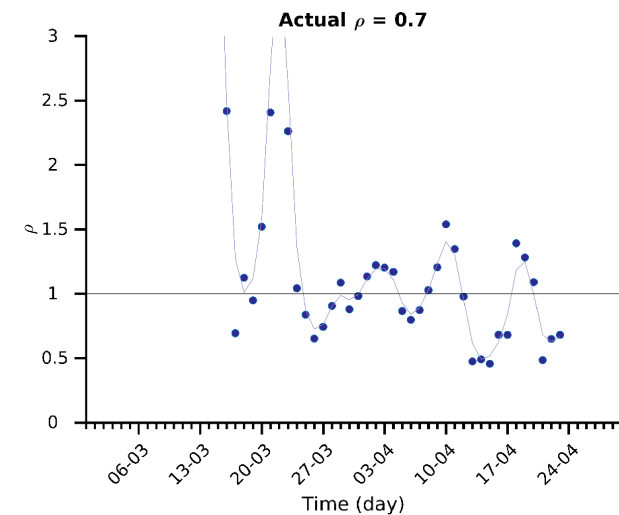
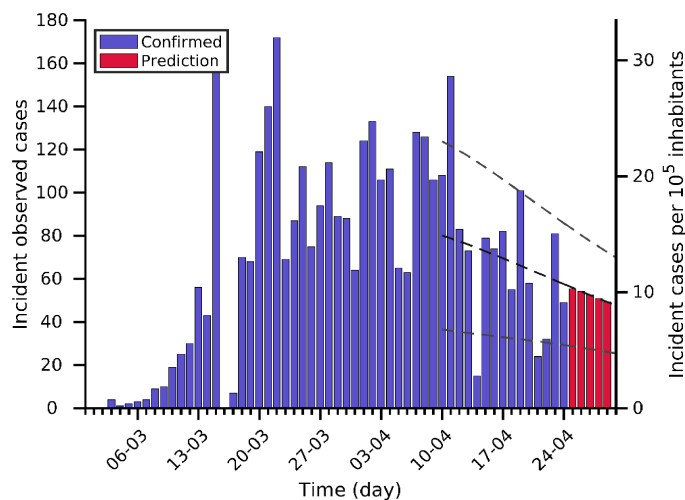
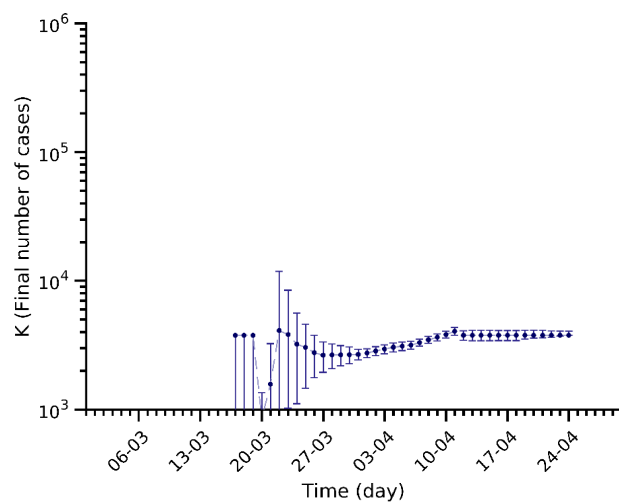
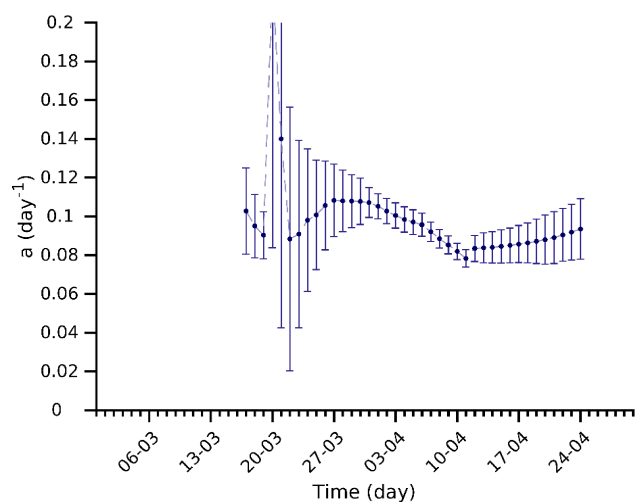
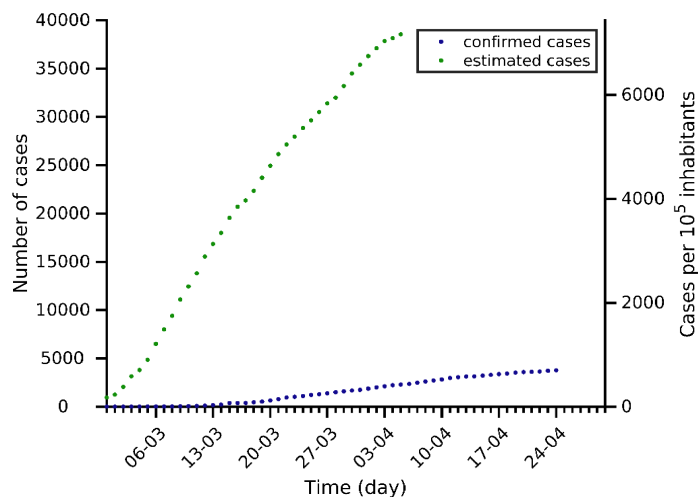
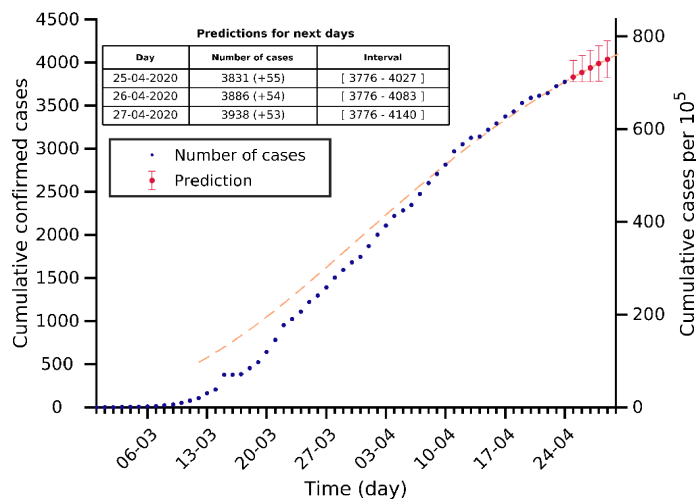
Campania 24-04-2020. Population: 5.8M. Current cumulated incidence: 74/10⁵



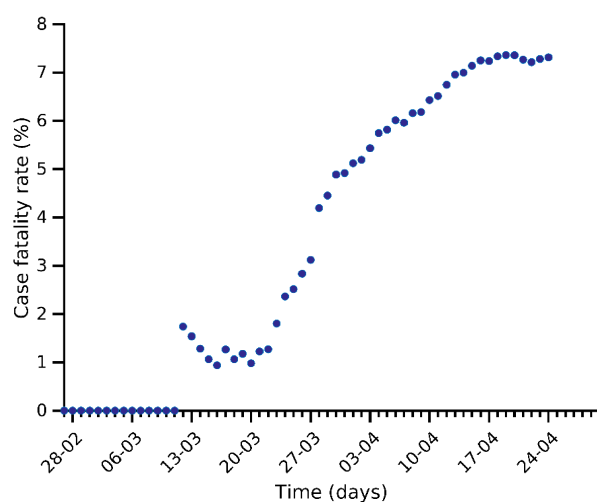
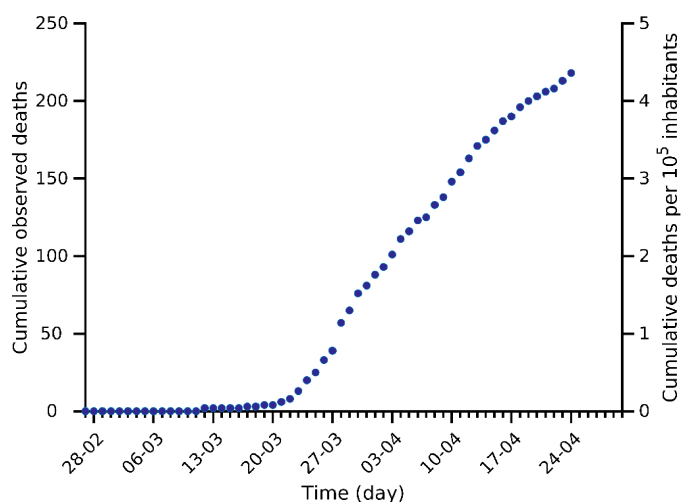
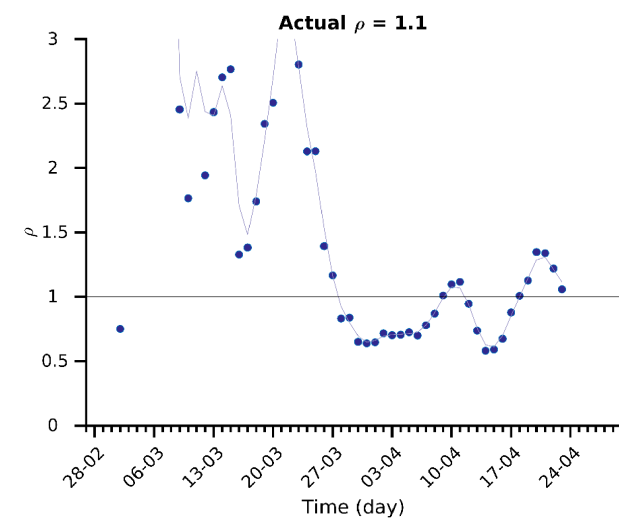
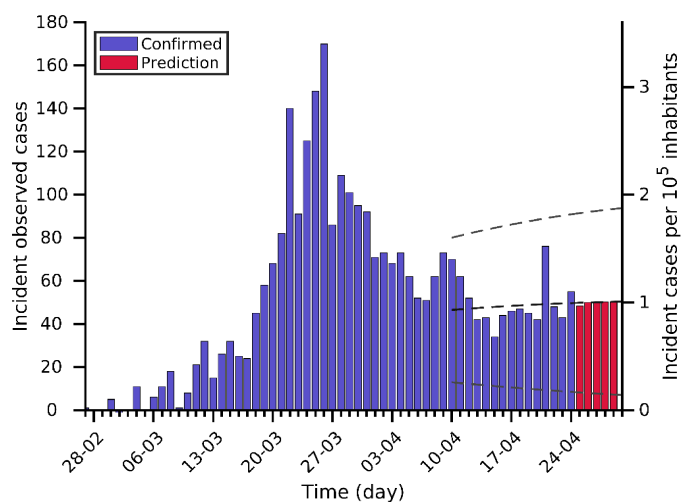
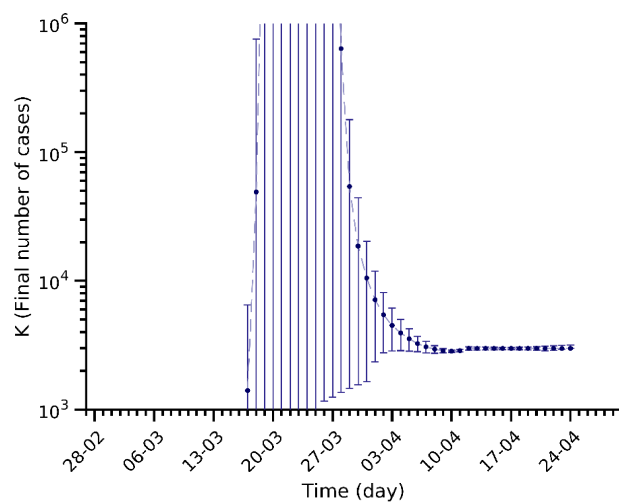
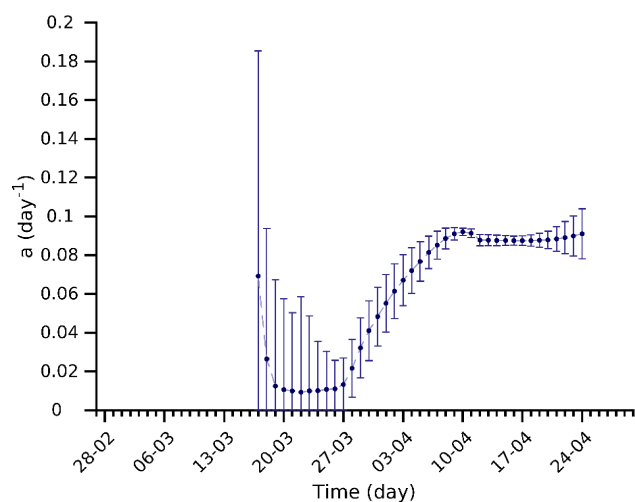
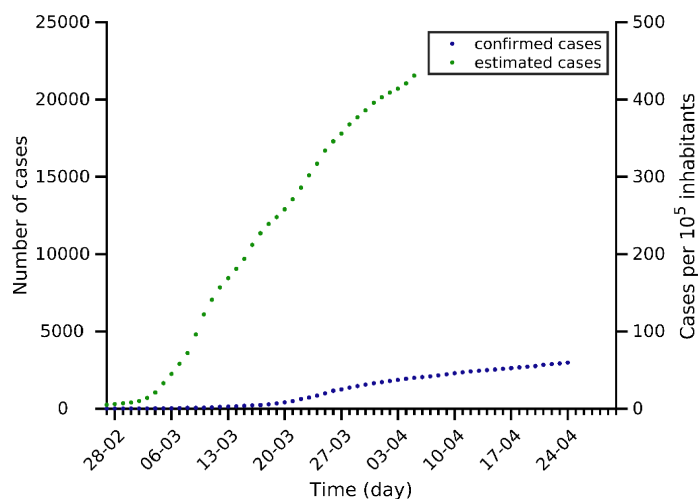
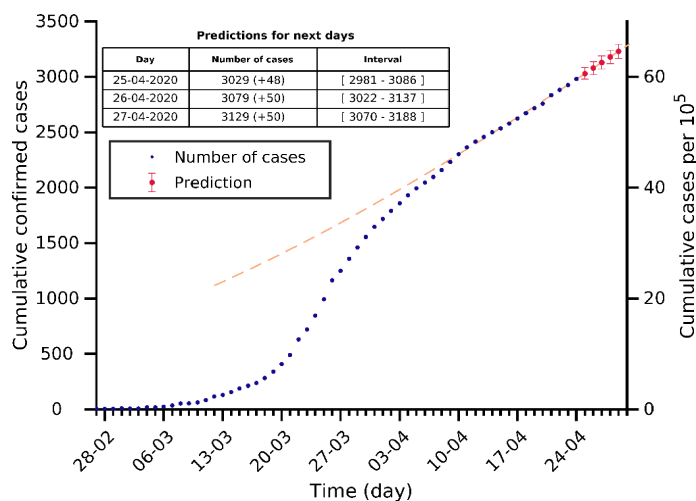
Puglia 24-04-2020. Population: 4.0M. Current cumulated incidence: 96/10⁵



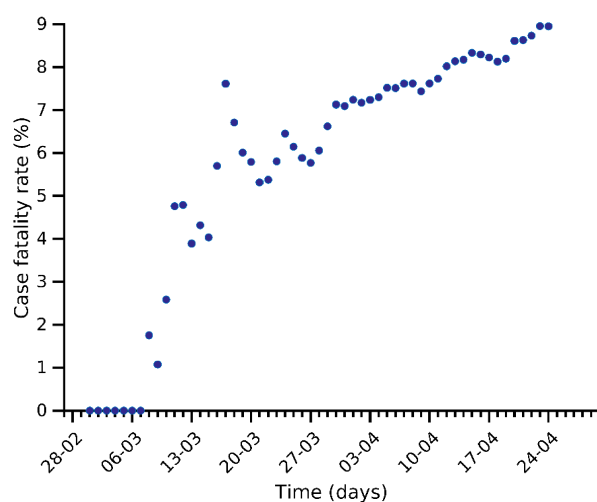
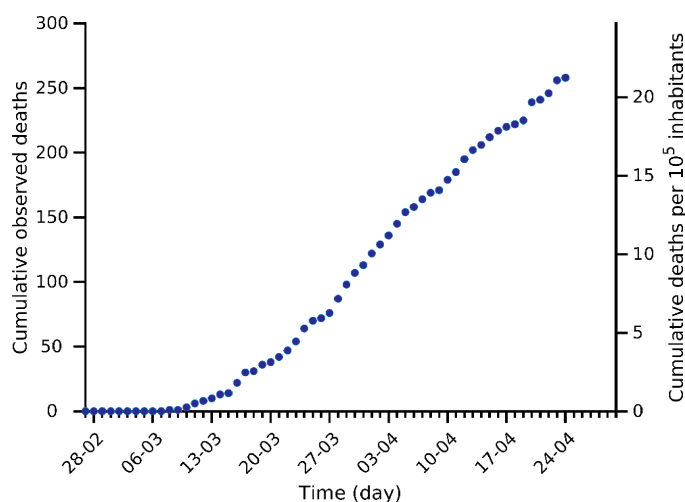
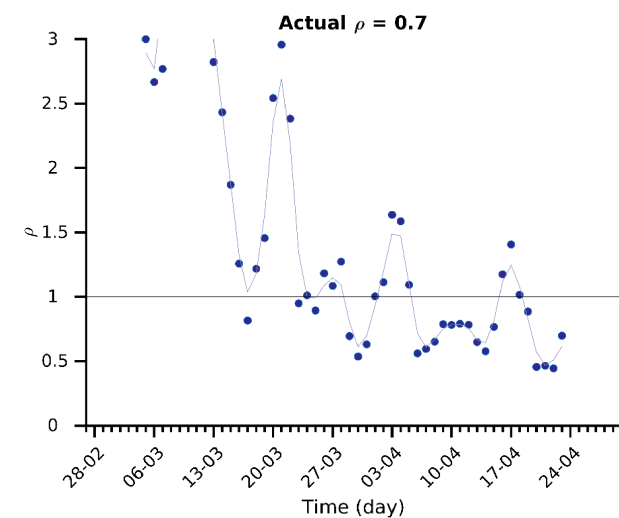
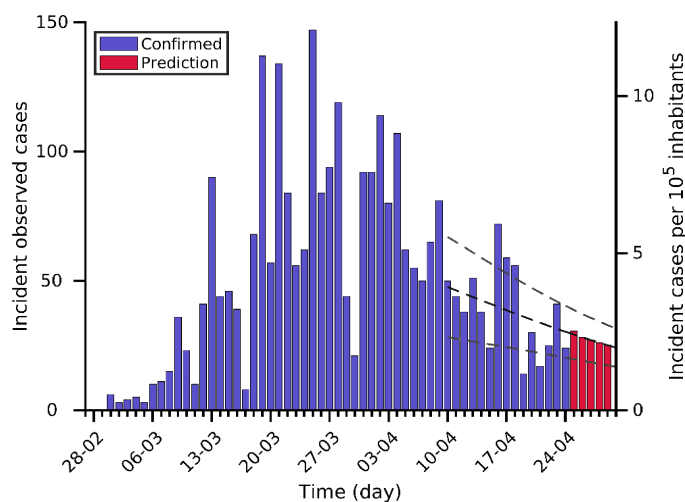
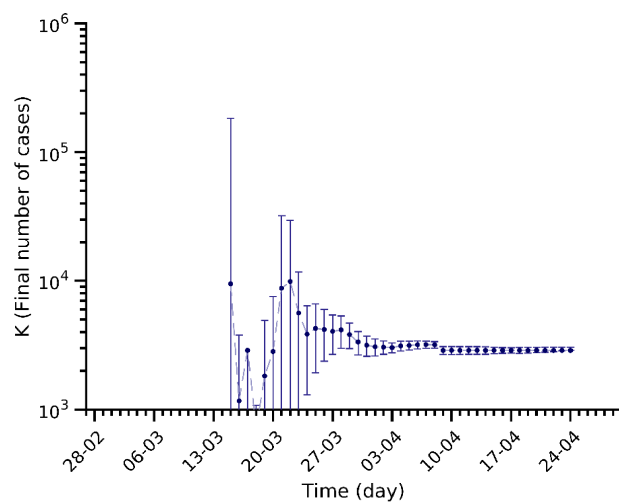
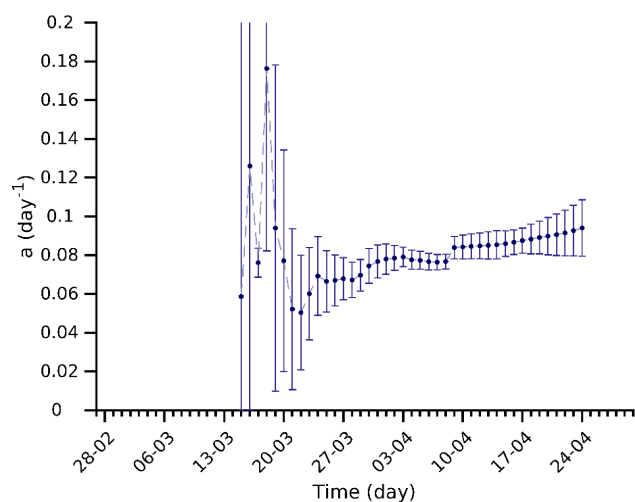
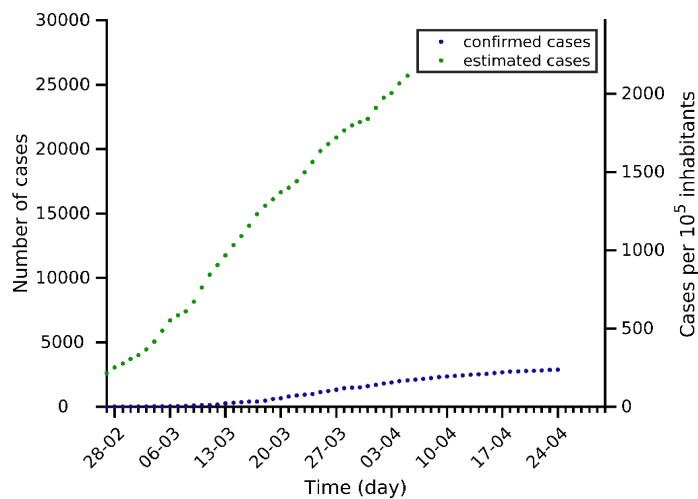
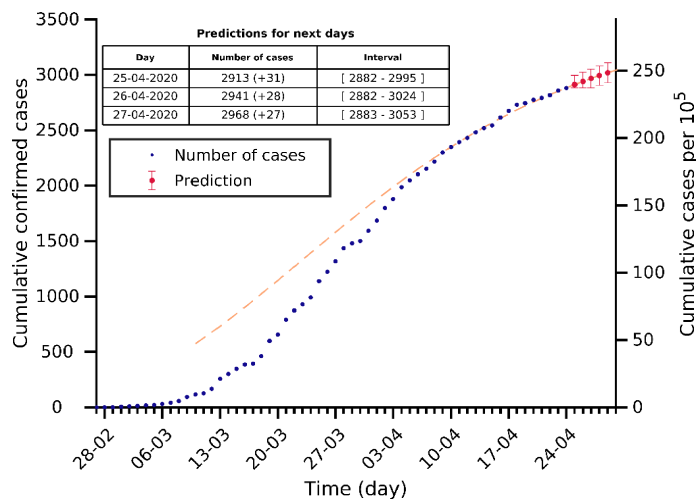
Trento 24-04-2020. Population: 0.5M. Current cumulated incidence: 702/10⁵



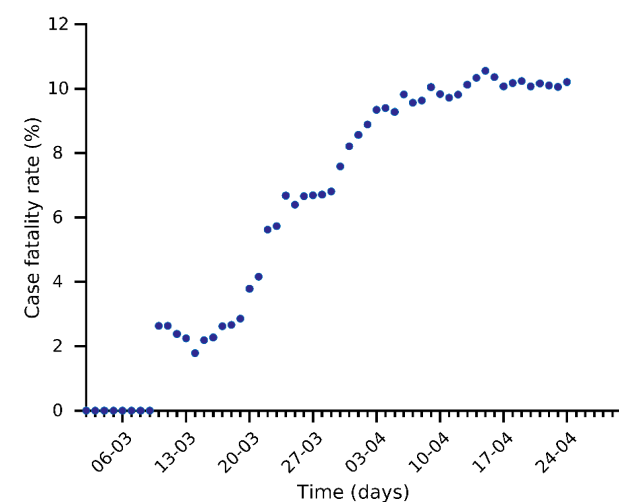
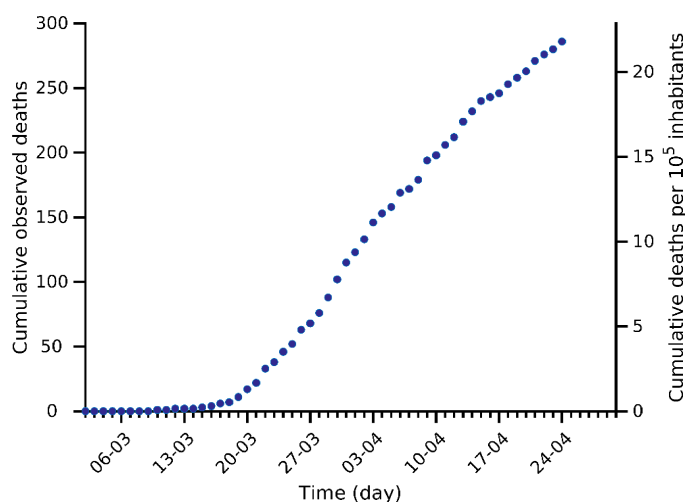
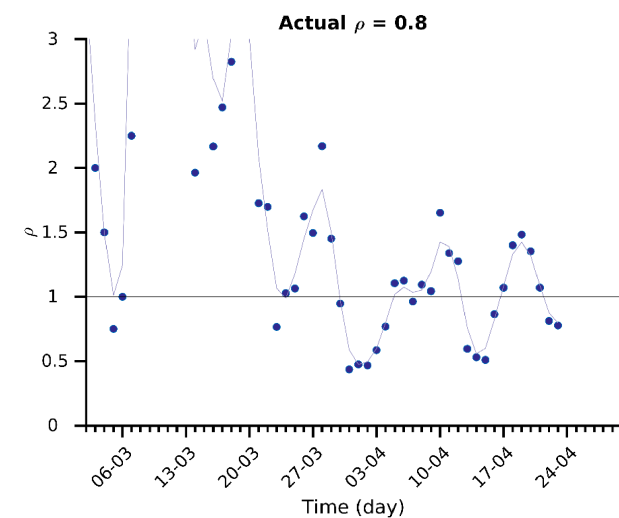
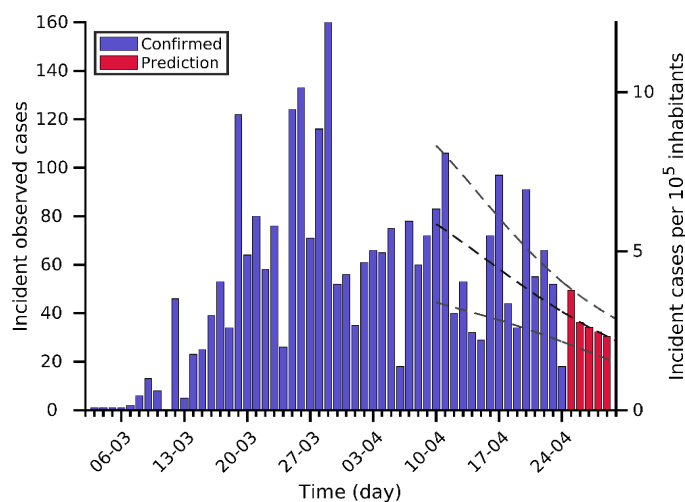
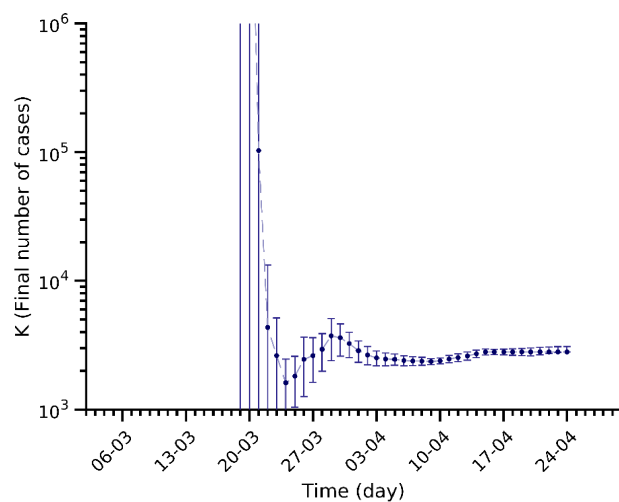
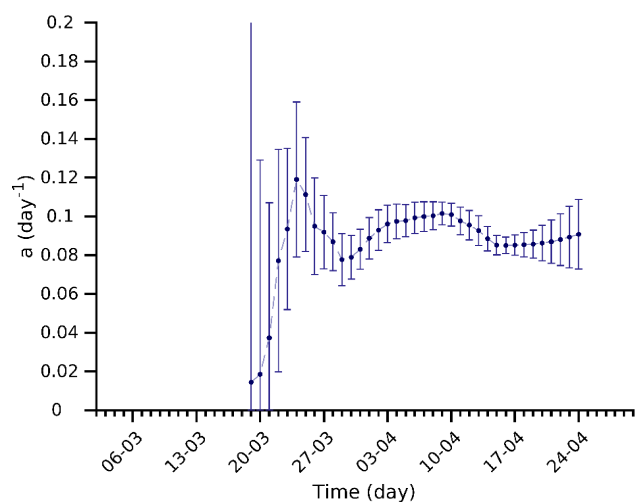
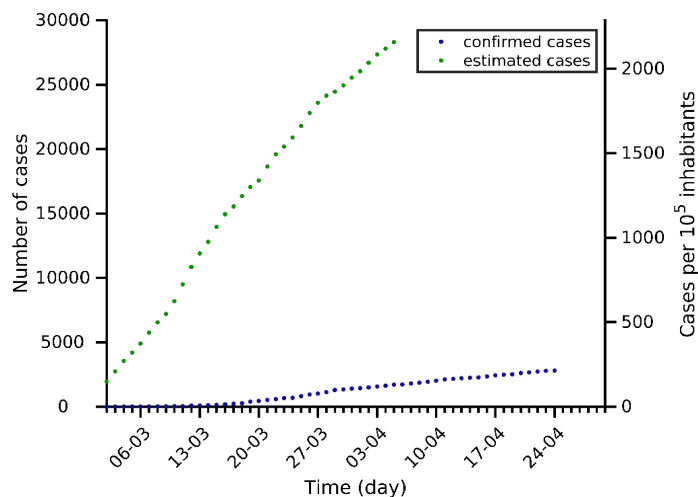
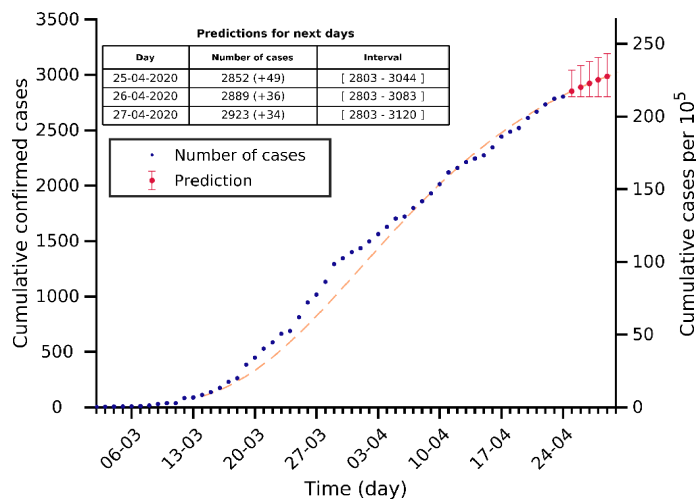
Sicilia 24-04-2020. Population: 5.0M. Current cumulated incidence: 60/10⁵



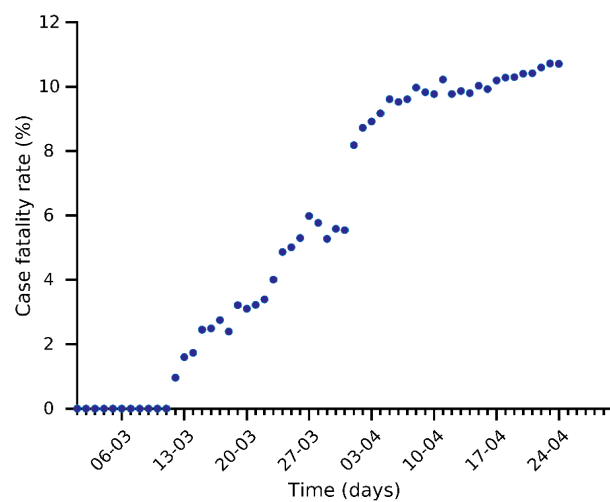
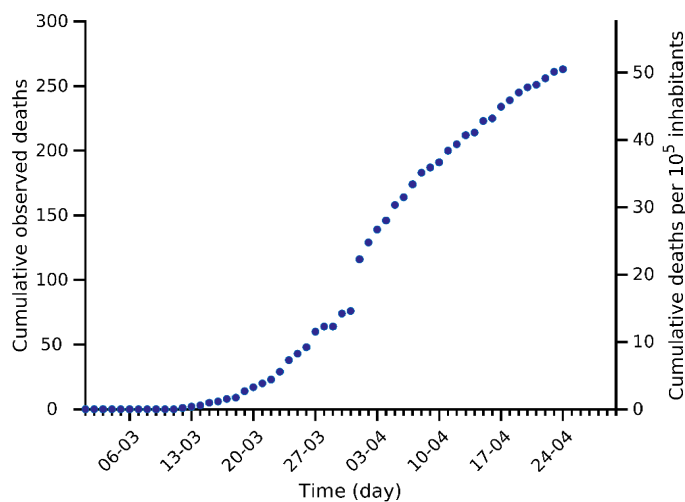
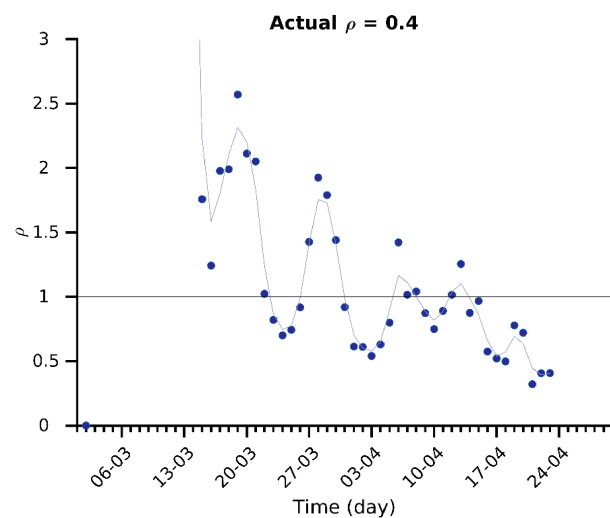
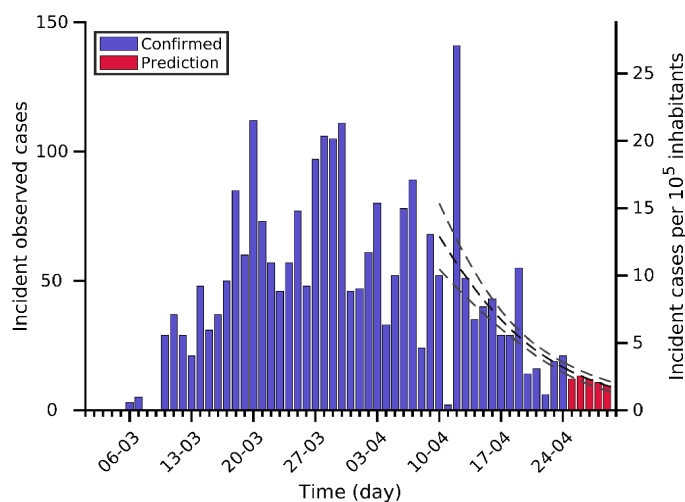
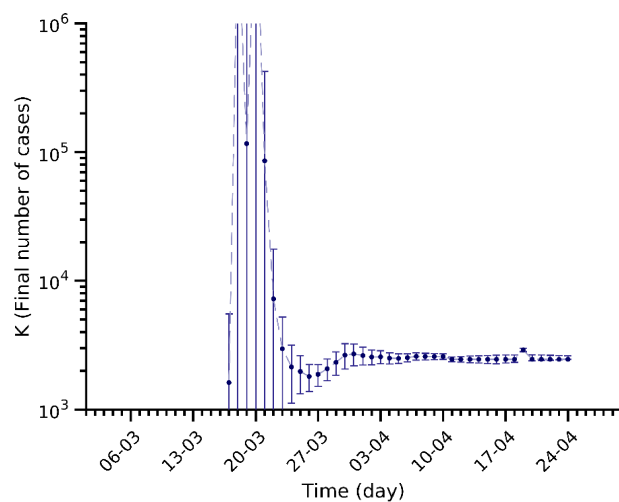
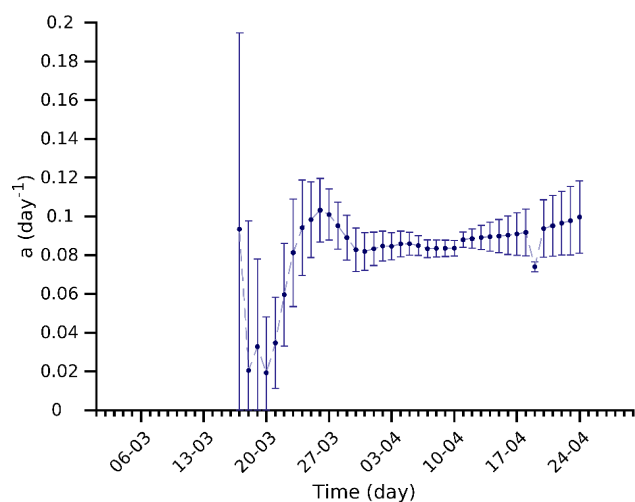
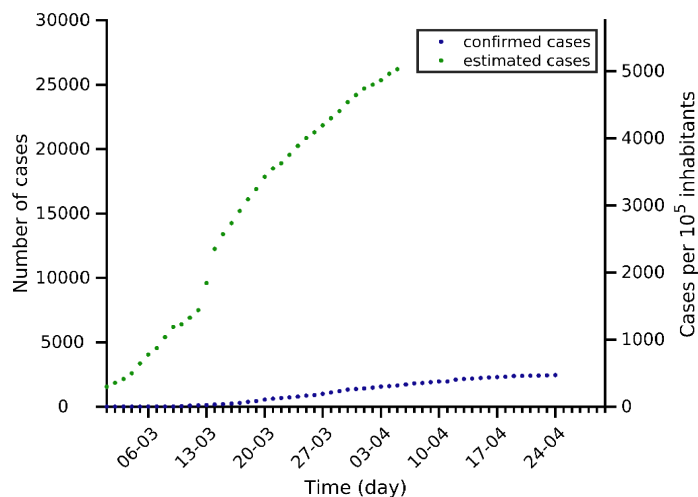
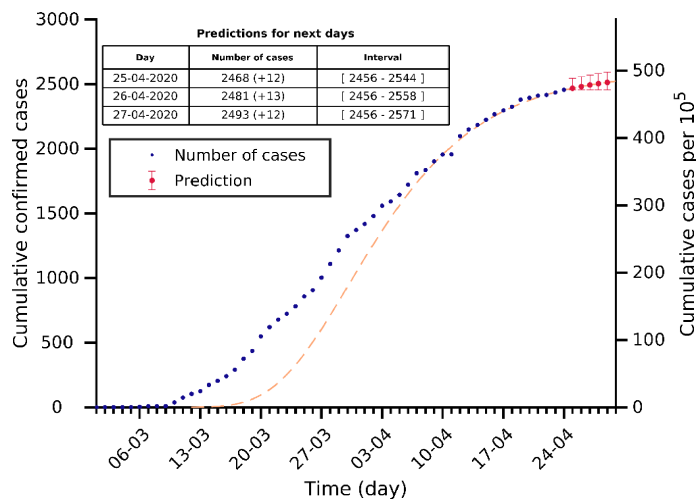
Friuli Venezia Giulia 24-04-2020. Population: 1.2M. Current cumulated incidence: 2



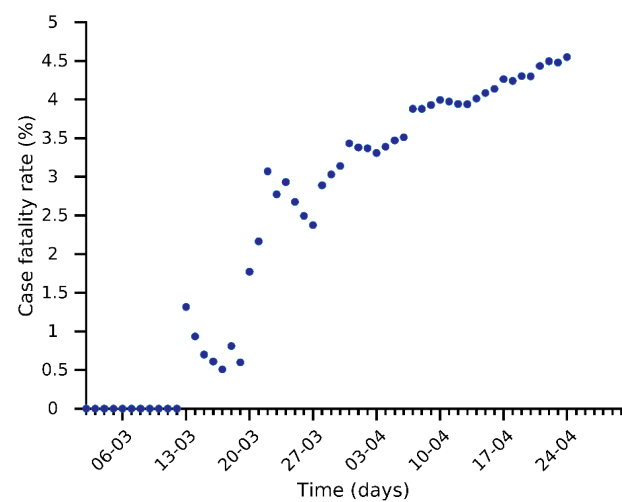
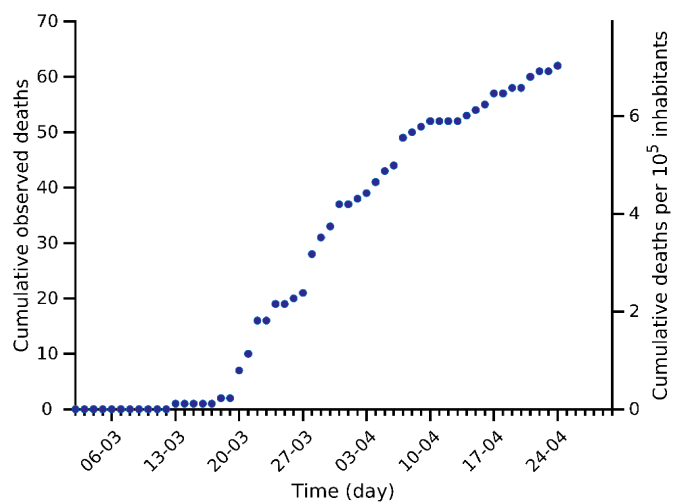
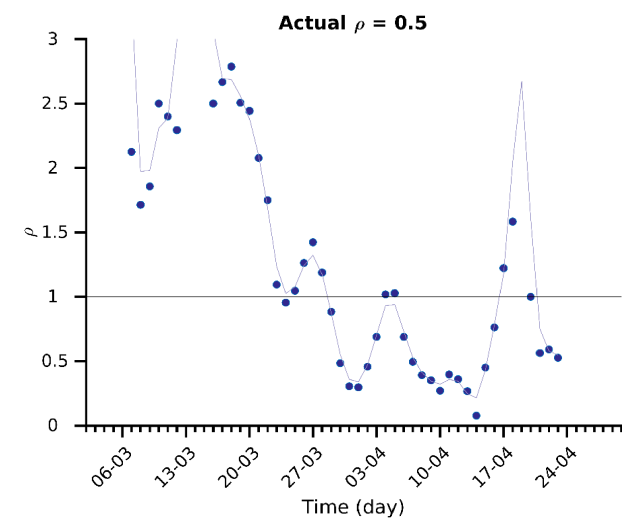
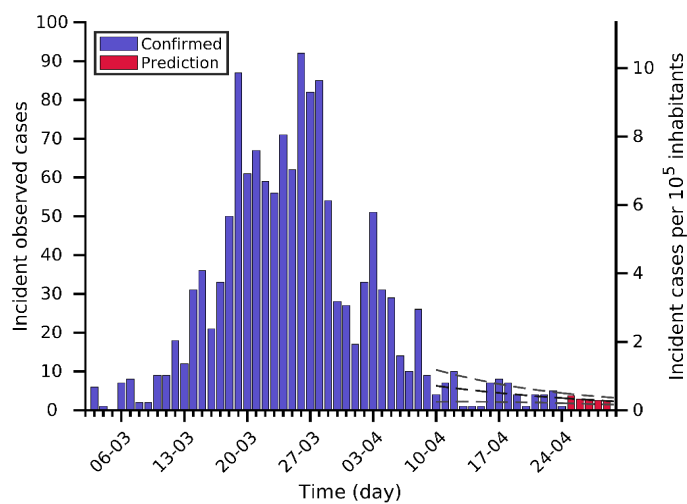
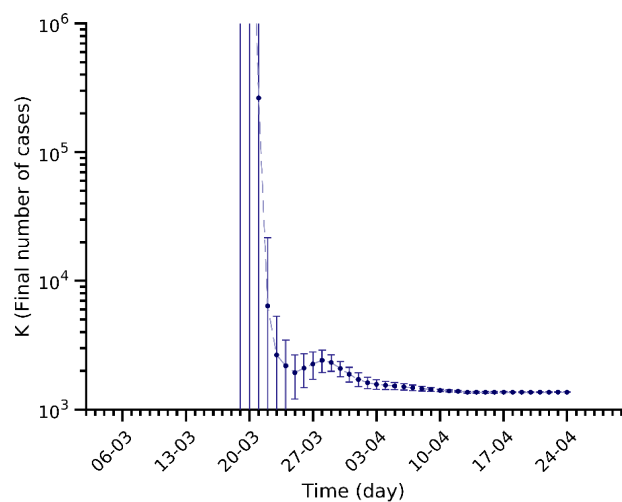
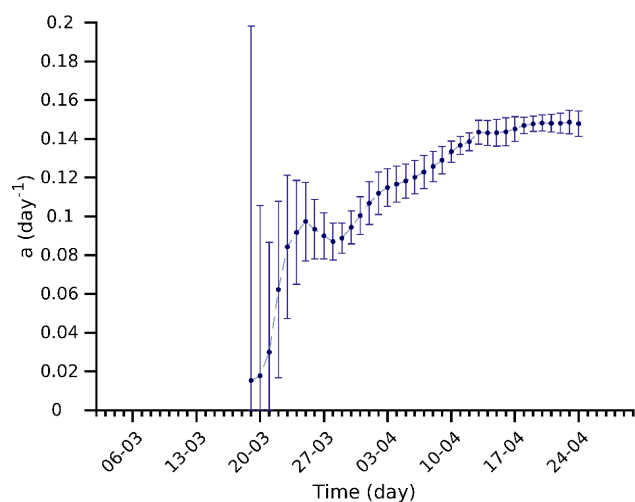
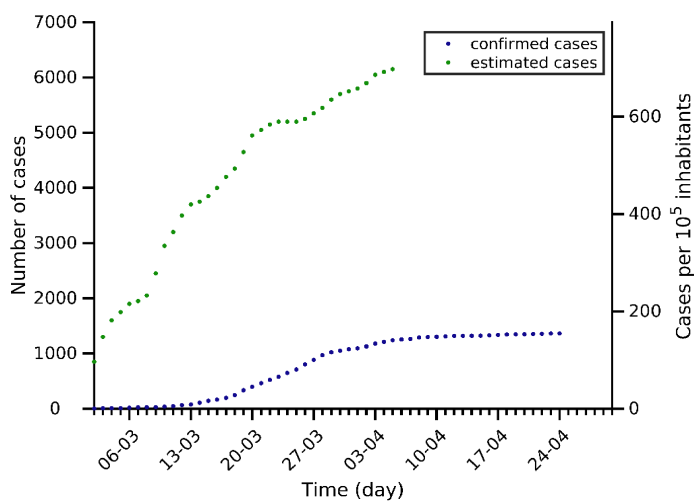
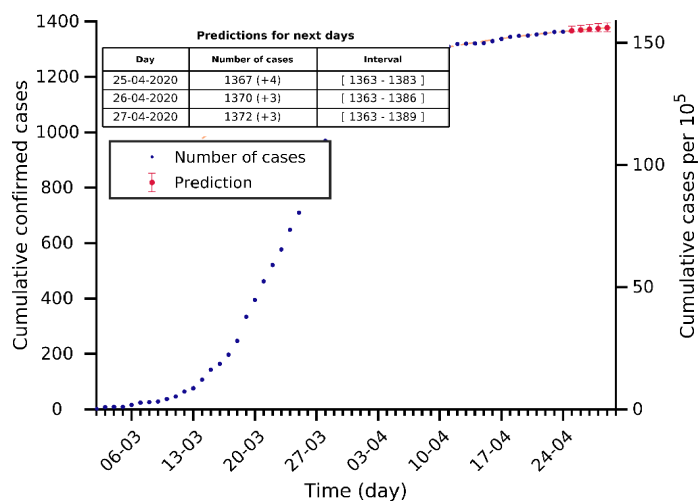
Abruzzo 24-04-2020. Population: 1.3M. Current cumulated incidence: 214/10⁵



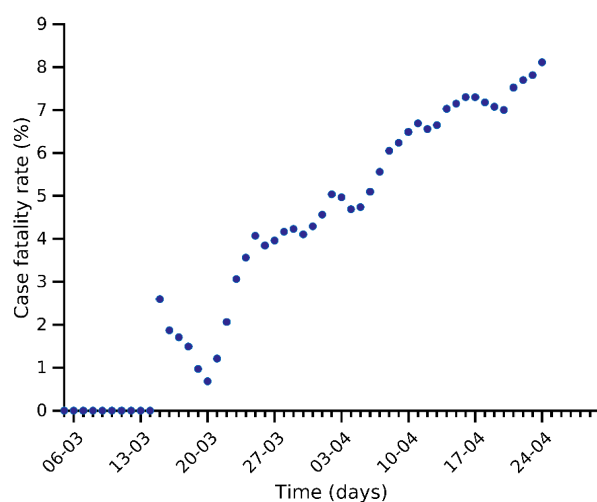
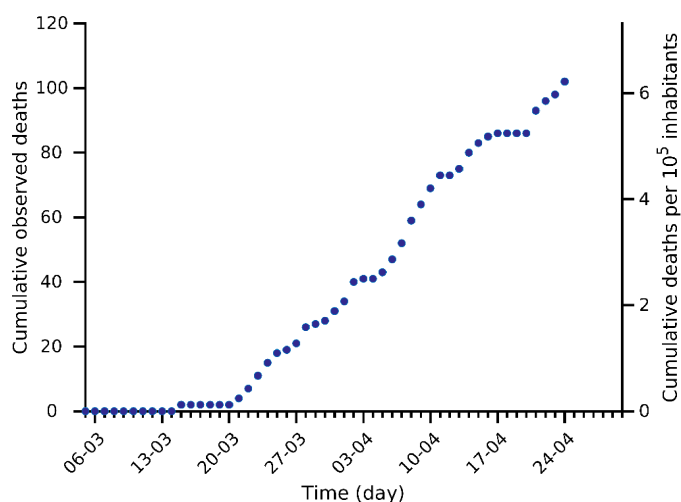
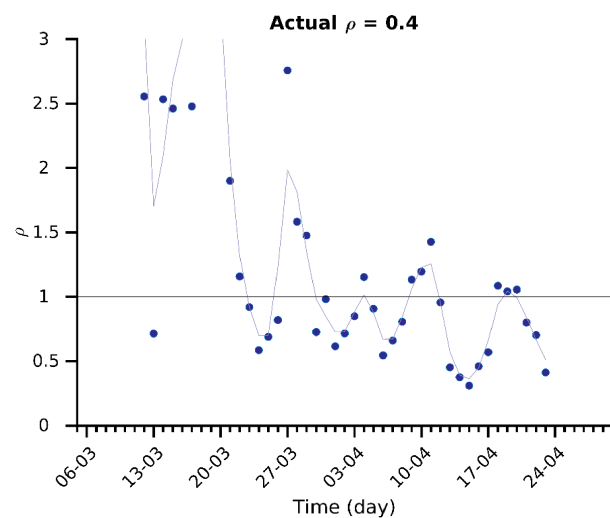
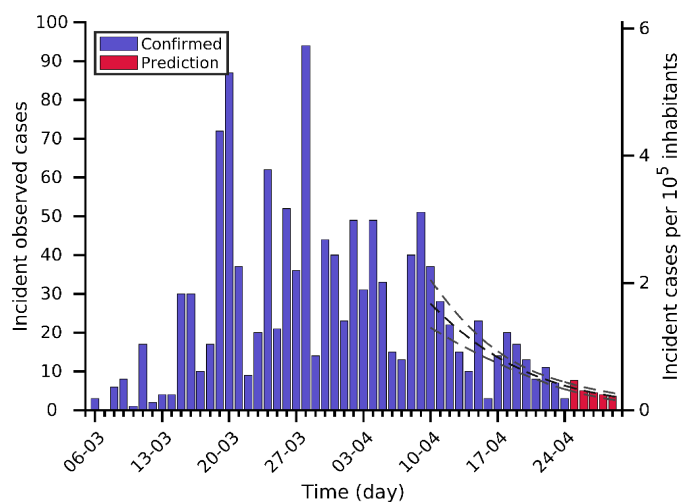
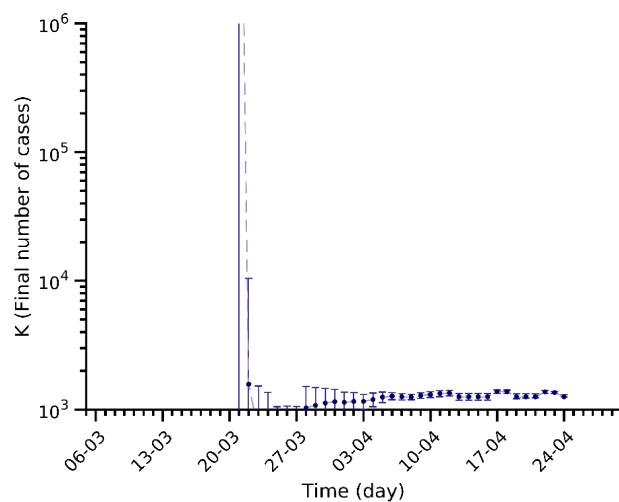
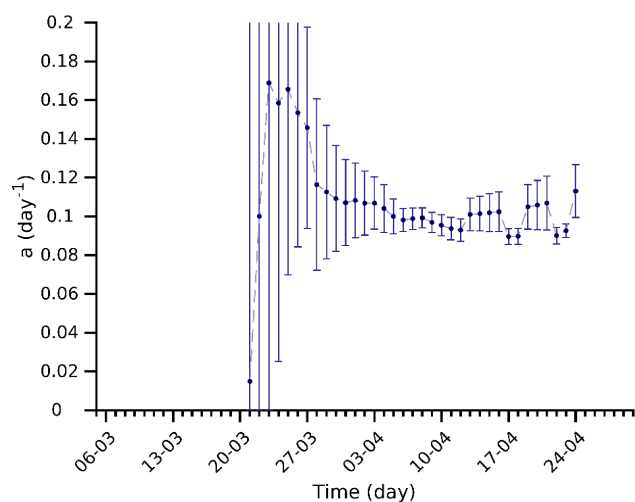
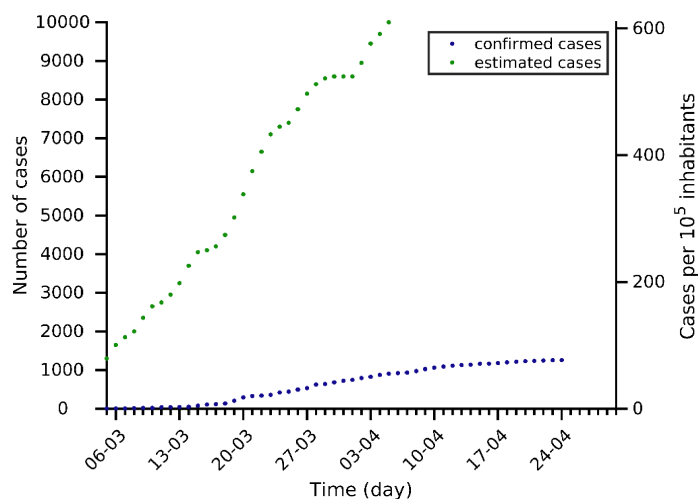
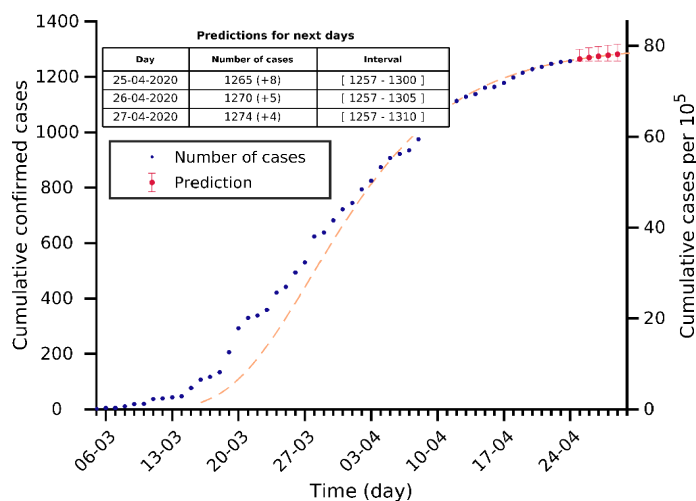
Bolzano 24-04-2020. Population: 0.5M. Current cumulated incidence: 471/10⁵



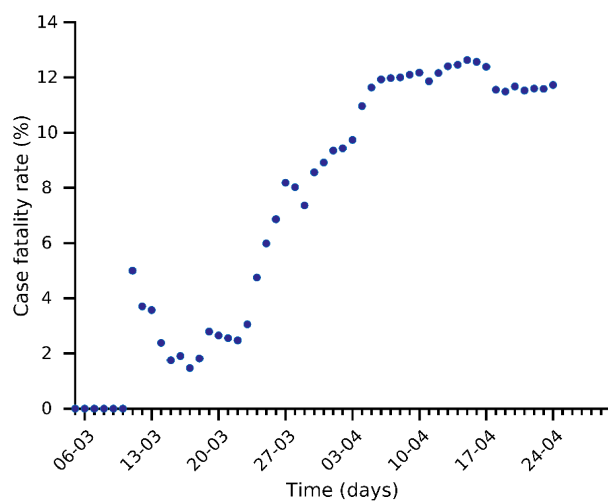
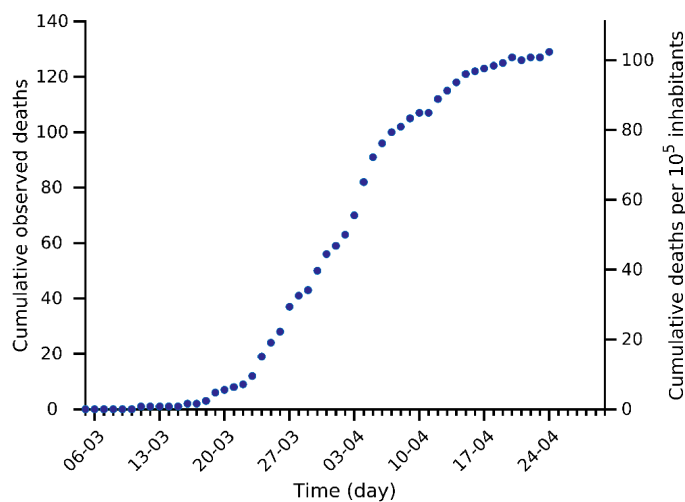
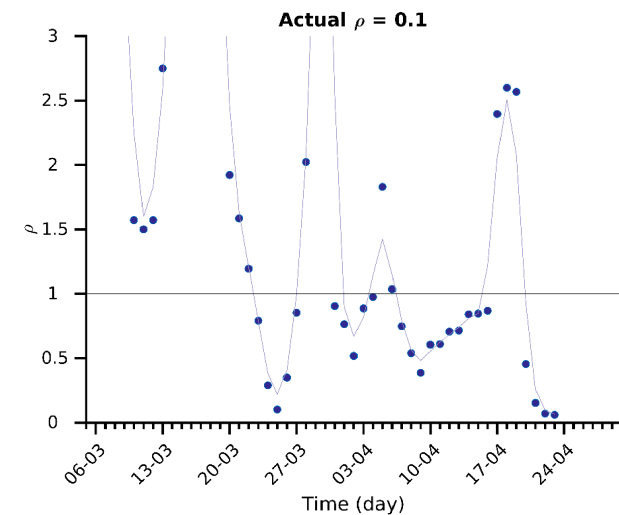
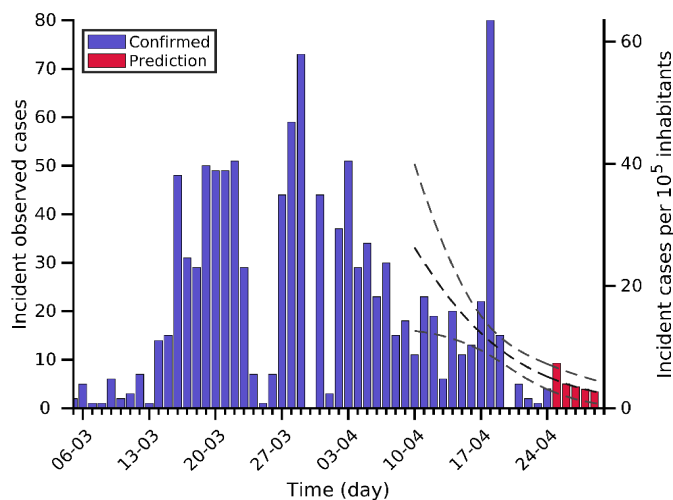
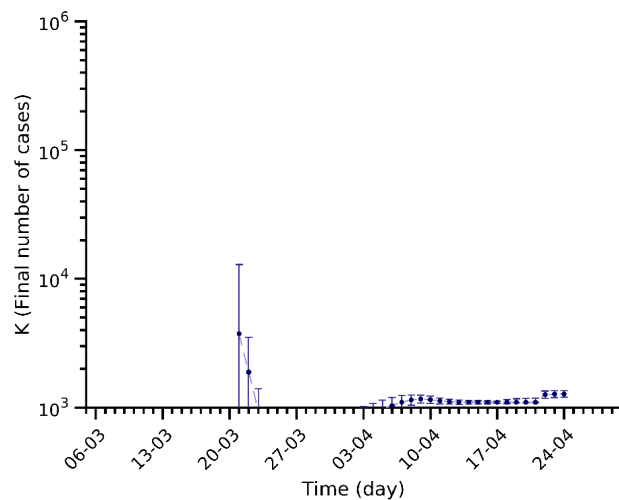
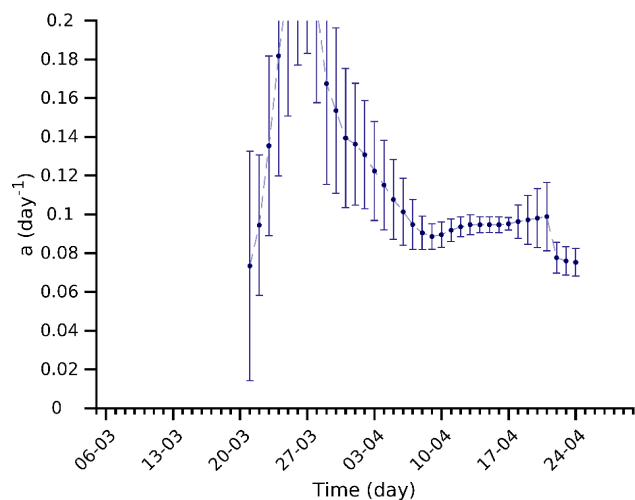
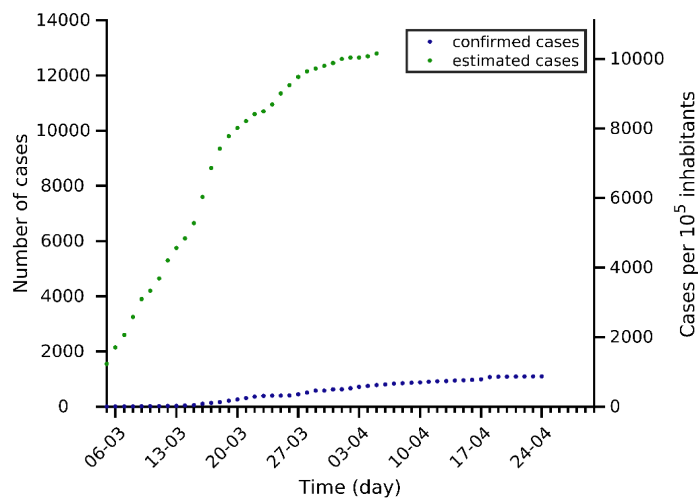
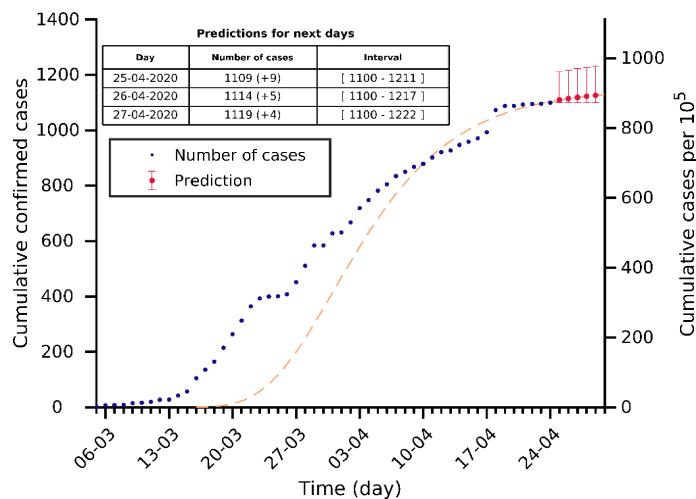
Umbria 24-04-2020. Population: 0.9M. Current cumulated incidence: 155/10⁵



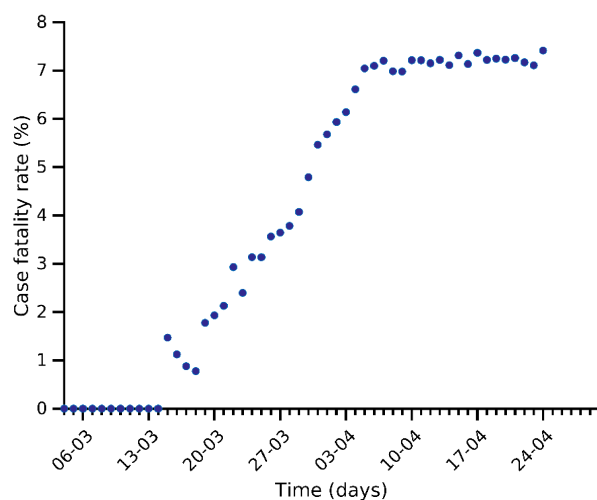
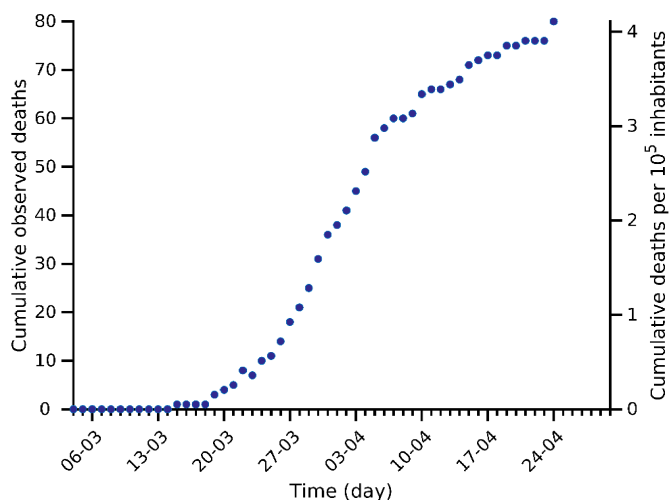
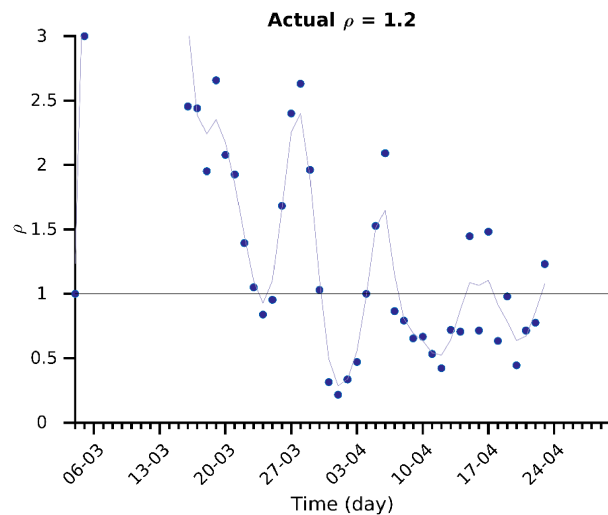
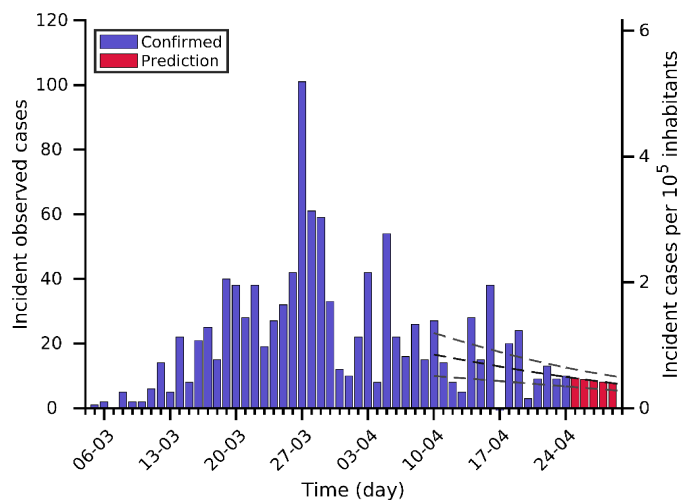
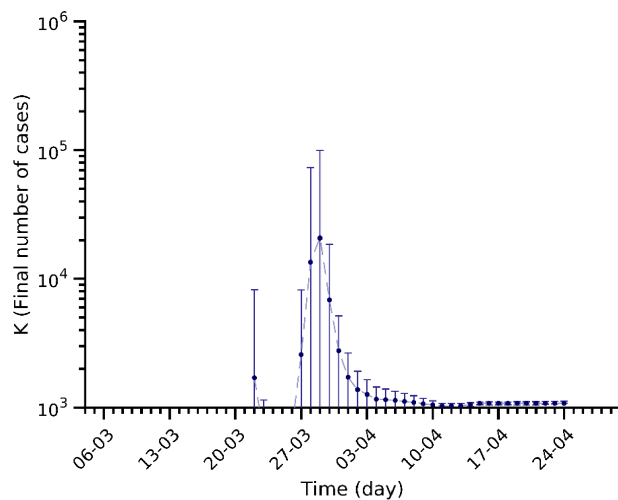
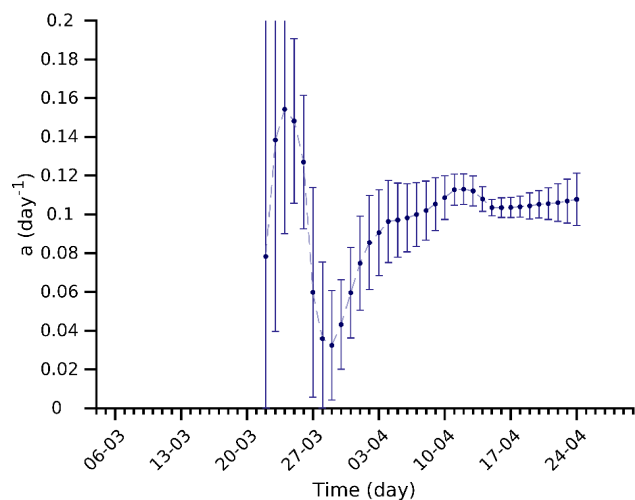
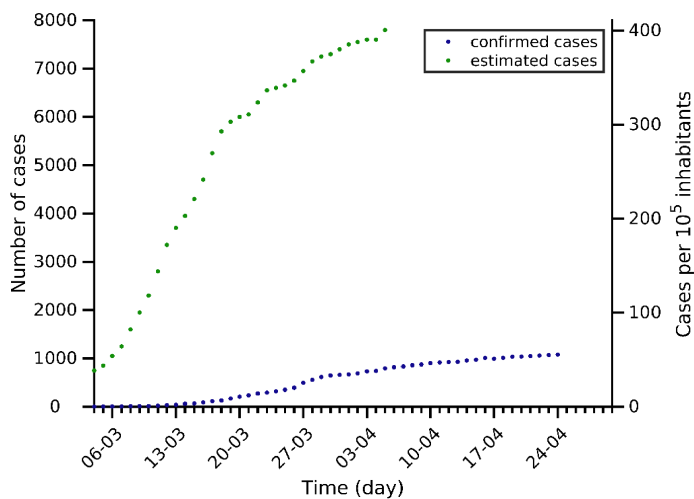
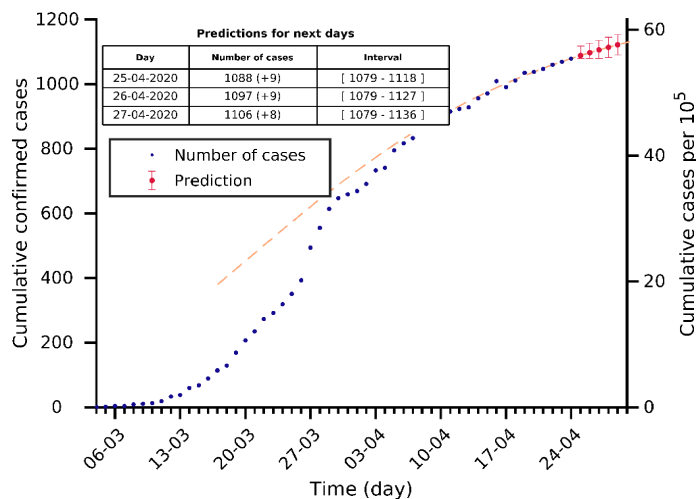
Sardegna 24-04-2020. Population: 1.6M. Current cumulated incidence: 77/10⁵



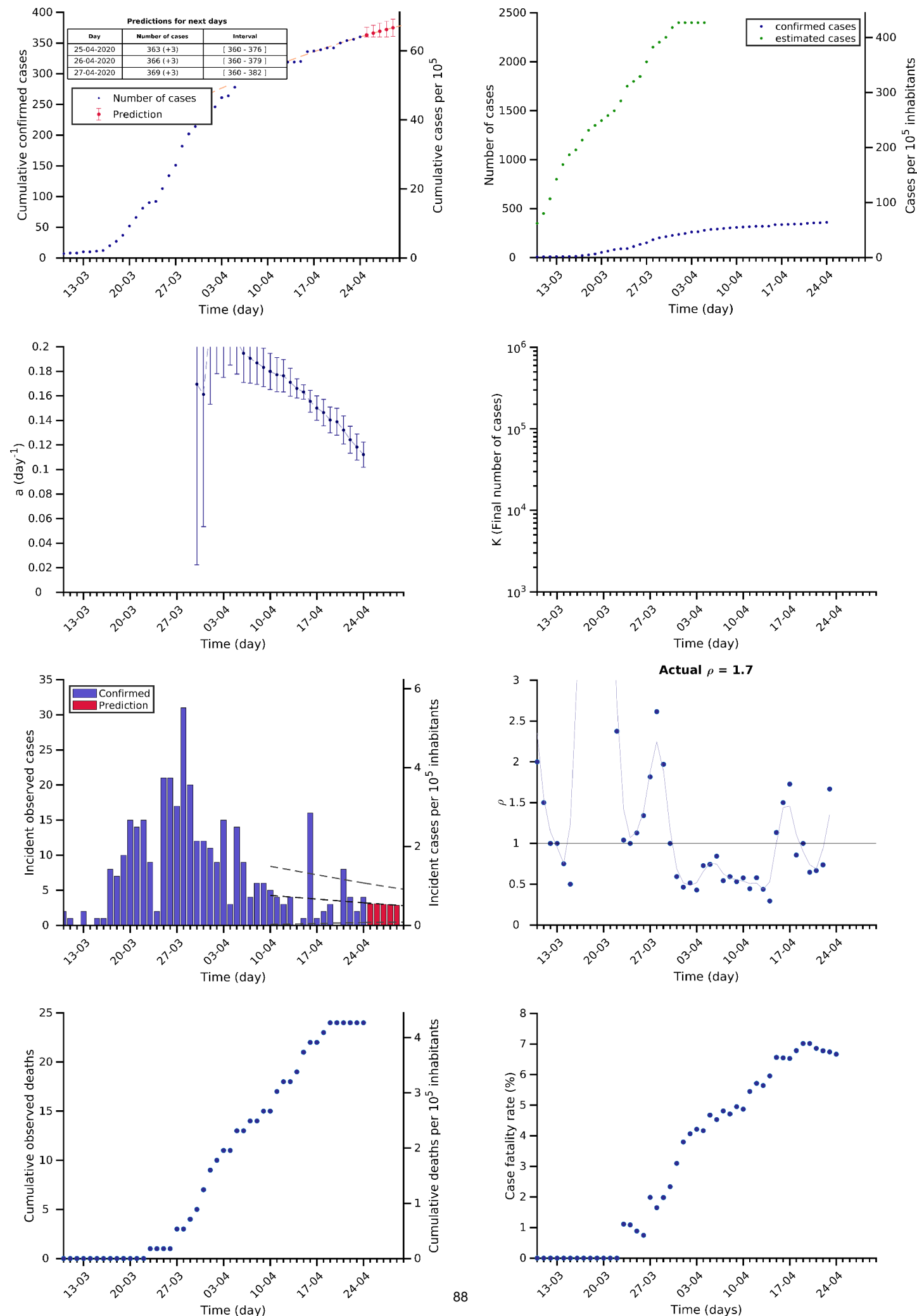
Valle d'Aosta 24-04-2020. Population: 0.1M. Current cumulated incidence: 873/10⁵



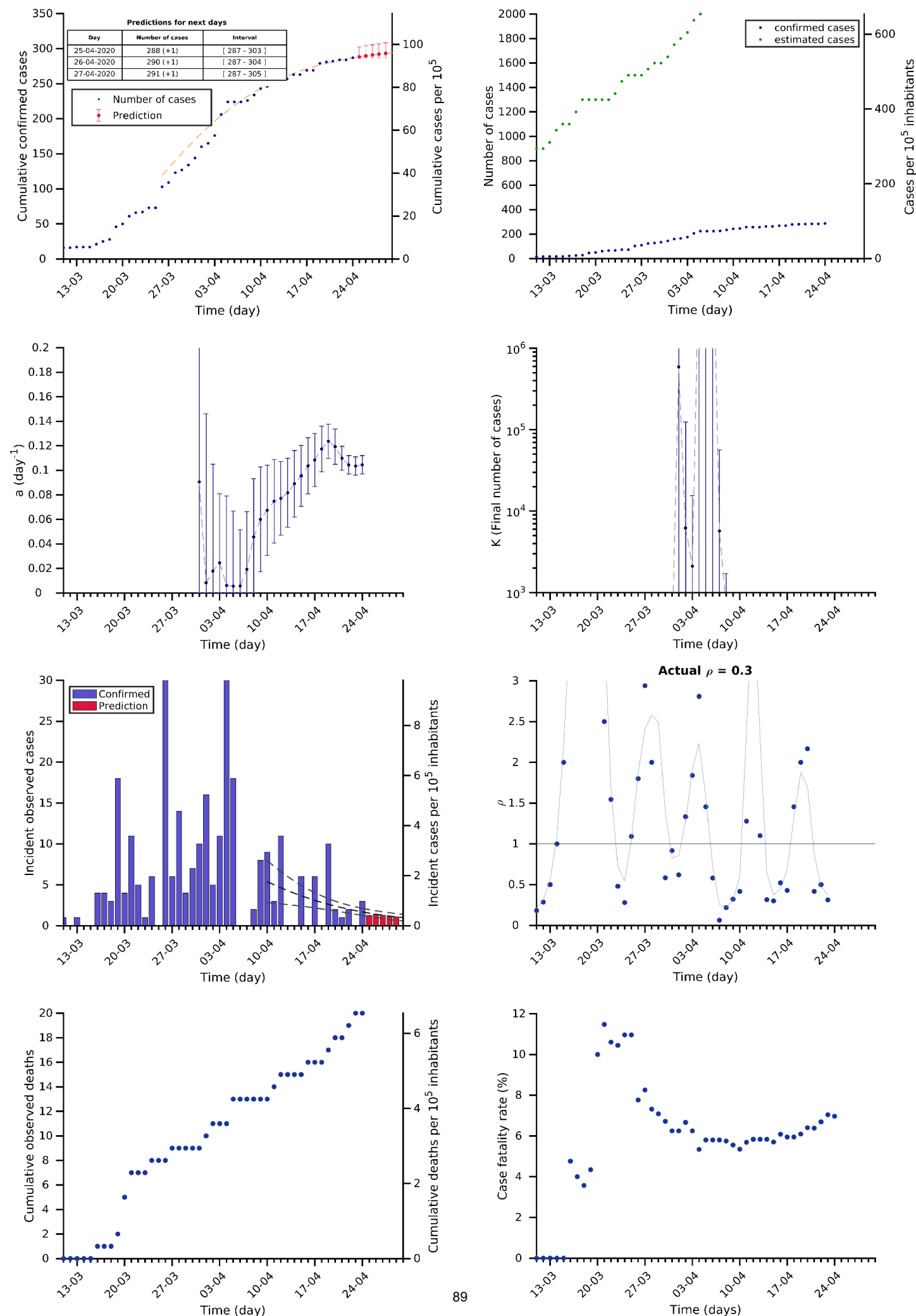
Calabria 24-04-2020. Population: 1.9M. Current cumulated incidence: 55/10⁵



Basilicata 24-04-2020. Population: 0.6M. Current cumulated incidence: 64/10⁵



Molise 24-04-2020. Population: 0.3M. Current cumulated incidence: 94/10⁵



Methods

Methods

(1) Data source

Data are daily obtained from World Health Organization (WHO) surveillance reports¹, from European Centre for Disease Prevention and Control (ECDC)² and from Ministerio de Sanidad³. These reports are converted into text files that can be processed for subsequent analysis. Daily data comprise, among others: total confirmed cases, total confirmed new cases, total deaths, total new deaths. It must be considered that the report is always providing data from previous day. In the document we use the date at which the datapoint is assumed to belong, i.e., report from 15/03/2020 is giving data from 14/03/2020, the latter being used in the subsequent analysis.

(2) Data processing and plotting

Data are initially processed with Matlab in order to update timeseries, i.e., last datapoints are added to historical sequences. These timeseries are plotted for EU individual countries and for the UE as a whole:

- ✓ Number of cumulated confirmed cases, in blue dots
- ✓ Number of reported new cases
- ✓ Number of cumulated deaths

Then, two indicators are calculated and plotted, too:

- ✓ Number of cumulated deaths divided by the number of cumulated confirmed cases, and reported as a percentage; it is an indirect indicator of the diagnostic level.
- ✓ ρ : this variable is related with the reproduction number, i.e., with the number of new infections caused by a single case. It is evaluated as follows for the day before last report ($t-1$):

$$\rho(t-1) = \frac{N_{new}(t) + N_{new}(t-1) + N_{new}(t-2)}{N_{new}(t-5) + N_{new}(t-6) + N_{new}(t-7)}$$

where $N_{new}(t)$ is the number of new confirmed cases at day t .

(3) Classification of countries according to their status in the epidemic cycle

The evolution of confirmed cases shows a biphasic behaviour:

- (I) an initial period where most of the cases are imported;
- (II) a subsequent period where most of new cases occur because of local transmission.

Once in the stage II, mathematical models can be used to track evolutions and predict tendencies. Focusing on countries that are on stage II, we classify them in three groups:

- Group A: countries that have reported more than 100 cumulated cases for 10 consecutive days or more;
- Group B: countries that have reported more than 100 cumulated cases for 7 to 9 consecutive days;
- Group C: countries that have reported more than 100 cumulated cases for 4 to 6 days.

¹ <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports>

² <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

³ <https://www.mscbs.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov-China/situacionActual.htm>
<https://github.com/datadista/datasets/tree/master/COVID%2019>

(4) Fitting a mathematical model to data

Previous studies have shown that Gompertz model⁴ correctly describes the Covid-19 epidemic in all analysed countries. It is an empirical model that starts with an exponential growth but that gradually decreases its specific growth rate. Therefore, it is adequate for describing an epidemic that is characterized by an initial exponential growth but a progressive decrease in spreading velocity provided that appropriate control measures are applied.

Gompertz model is described by the equation:

$$N(t) = K e^{-\ln\left(\frac{K}{N_0}\right) \cdot e^{-a \cdot (t-t_0)}}$$

where $N(t)$ is the cumulated number of confirmed cases at t (in days), and N_0 is the number of cumulated cases the day at day t_0 . The model has two parameters:

- ✓ a is the velocity at which specific spreading rate is slowing down;
- ✓ K is the expected final number of cumulated cases at the end of the epidemic.

This model is fitted to reported cumulated cases of the UE and of countries in stage II that accomplish two criteria: 4 or more consecutive days with more than 100 cumulated cases, and at least one datapoint over 200 cases. Day t_0 is chosen as that one at which $N(t)$ overpasses 100 cases. If more than 15 datapoints that accomplish the stated criteria are available, only the last 15 points are used. The fitting is done using Matlab's Curve Fitting package with Nonlinear Least Squares method, which also provides confidence intervals of fitted parameters (a and K) and the R^2 of the fitting. At the initial stages the dynamics is exponential and K cannot be correctly evaluated. In fact, at this stage the most relevant parameter is a . Fitted curves are incorporated to plots of cumulative reported cases with a dashed line. Once a new fitting is done, two plots are added to the country report:

- ✓ Evolution of fitted a with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out;
- ✓ Evolution of fitted K with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out; if lower error bar indicates a value that is lower than current number of cases, the error bar is truncated.

These plots illustrate the increase in fittings' confidence, as fitted values progressively stabilize around a certain value and error bars get smaller when the number of datapoints increases. In fact, in the case of countries, they are discarded and set as "Not enough data" if $a > 0.2 \text{ day}^{-1}$, if $K > 10^6$ or if the error in K overpasses 10^6 .

It is worth to mention that the simplicity of this model and the lack of previous assumptions about the Covid-19 behaviour make it appropriate for universal use, i.e., it can be fitted to any country independently of its socioeconomic context and control strategy. Then, the model is capable of quantifying the observed dynamics in an objective and standard manner and predicting short-term tendencies.

(5) Using the model for predicting short-term tendencies

The model is finally used for a short-term prediction of the evolution of the cumulated number of cases. The predictions increase their reliability with the number of datapoints used in the fitting. Therefore, we consider three levels of prediction, depending on the country:

⁴ Madden LV. Quantification of disease progression. Protection Ecology 1980; 2: 159-176.

- Group A: prediction of expected cumulated cases for the following 3-5 days⁵;
- Group B: prediction of expected cumulated cases for the following 2 days;
- Group C: prediction of expected cumulated cases for the following day.

The confidence interval of predictions is assessed with the Matlab function `predint`, with a 99% confidence level. These predictions are shown in the plots as red dots with corresponding error bars, and also gathered in the attached table. For series longer than 9 timepoints, last 3 points are weighted in the fitting so that changes in tendencies are well captured by the model.

(6) Estimating non-diagnosed cases

Lethality of Covid-19 has been estimated at around 1 % for Republic of Korea and the Diamond Princess cruise. Besides, median duration of viral shedding after Covid-19 onset has been estimated at 18.5 days for non-survivors⁶ in a retrospective study in Wuhan. These data allow for an estimation of total number of cases, considering that the number of deaths at certain moment should be about 1 % of total cases 18.5 days before. This is valid for estimating cases of countries at stage II, since in stage I the deaths would be mostly due to the incidence at the country from which they were imported. We establish a threshold of 50 reported cases before starting this estimation.

Reported deaths are passed through a moving average filter of 5 points in order to smooth tendencies. Then, the corresponding number of cases is found assuming the 1 % lethality. Finally, these cases are distributed between 18 and 19 days before each one.

⁵ At this moment we are testing predictions at 4 days for countries with more than 100 cumulated cases for 13-15 consecutive days, and 5 days for 16 or more days.

⁶ Zhou et al., 2020. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. The Lancet; March 9, doi: 10.1016/S0140-6736(20)30566-3